Annex I

Democratic Socialist Republic of Sri Lanka

National Policy on Climate Change

November - 2023

Ministry of Environment

National Policy on Climate Change

Climate Change Secretariat
Ministry of Environment
"Sobadam Piyasa"
Robert Gunawardena Mawatha,
Battaramulla.

National Policy on Climate Change

Published by : Climate Change Secretariat
Ministry of Environment
"Sobadam Piyasa", Robert Gunawardena Mawatha,
Battaramulla.

ISBN : 978-624-5817-37-5

Printed by : Fetch Corporate (Pvt) Ltd.
No. 51, E.S Fernando Mawatha,
Wellawatte, Colombo - 06.
Tel: 011 2 362 667 / 077 7 065 154

Cabinet Memorandum 23/2256/604/220 on
'National Policy on Climate Change' has been approved
by the Cabinet of Ministers on 27 November 2023

Contents

Policy Name: National Policy on Climate Change

Effective Date: 2023 November 27

1. Introduction

(i) Background

Climate change impacts the society by disrupting the natural, economic, and social systems. A changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of weather and climate extremes, with a higher exposure of people and economic assets resultingin long-term increases in economic losses from climate-induced disasters.

Recent analysis has shown a slow but steady increase of both the maximum and minimum temperature in Sri Lanka. With an annual increment of ambient temperature at 0.01–0.03 °C since 1960[1], the day/night temperature difference has narrowed, especially enhancing the vulnerability of farming community in the cooler climates at higher elevations and increasing the number of warm days and nights. Further, the intensity and frequency of extreme weather events (e.g. heavy rainfall leading to floods, tornado- type winds, intense lightning strikes) are increasing in Sri Lanka, affecting all economic sectors.

Being in the frontline of climate change, Sri Lanka frequently faces repetitive climate-induced disasters with multiple impacts on economic development. Sri Lanka has been identified as one of the most vulnerable countries with an absolute annual loss estimated at USD 3,626 million attributed to climate change[2]. Climate-induced disasters have threatened

---

[1] Jayawardena, S., Dharshika, T., and Herath, R. (2017). Observed climate trends, future climate change projections and possible impacts for Sri Lanka. '*Neela Haritha*' the Climate Change Magazine of Sri Lanka, 2, 144–151

[2] WB and ADB (2021): Climate Risk Country Profile: Sri Lanka. The World Bank Group and the Asian Development Bank

Sri Lanka’s economic growth while the vulnerable communities in the country are suffering from deteriorating conditions resulting in climate change.

The updated Nationally Determined Contributions (NDCs) of 2021 has developed adaptation NDCs for the most critical sectors affected by climate change, namely, agriculture, fisheries, livestock, water,biodiversity, coastal and marine, health, urban planning and human settlements and tourism and recreation, which needs resilience-building actions. Sri Lanka has, thus, developed the National Adaptation Plan (NAP) for Climate Change Impacts and is also developing Provincial Adaptation Plans to ensure engagement of stakeholders at all levels in achieving climate resilience.

Sri Lanka is a low carbon emitting country with per capita emissions of around 1.02 tons/per person, and its development pathway has remained low-carbon-intensive. Despite having a relatively low carbon footprint, SriLanka is committed to reduce greenhouse gas (GHG) emissions in its updated NDCs by 14.5% with respect to BAU scenario from 2021 to 2030 in the Power (electricity generation), Transport, Industry, Waste, Forestry, and Agriculture sectors.

The National Environment Policy (NEP) and the National Environment Action Plan (NEAP) 2022- 2030 were adopted in Sri Lanka in 2022. The NEP clearly states that the human-induced adverse impacts on the environment, such as climate change, could derail the process of sustainable development. This would result in a collapse of life support systems, degradation and exhaustion of productive natural capital, a decline of overall productivity, and increased exposure of life and properties to natural hazards, which are often felt more by women and children since they bear the brunt of the climate crisis. People of Sri Lanka, especially women and youth, can act as agents of change to bring the required changes in the society to achieve required climate change mitigation and adaptation.

Climate-induced hazards in Sri Lanka has increased by 22-fold during the last decade compared to 1973-1983 with an increasing occurrences of catastrophic extreme weather events, and slow-onset events. Loss and Damage describe the harms inflicted by climate change that go beyond the limits of adaptation. The estimated damages and losses in Sri Lanka from the floods and landslides were more than USD 473 million in May 2016 and USD 368 million in May 2017[3]. The contingent liability of the government of Sri Lanka in 2017 was USD 149 million (approx. 1% of totalgovernment expenditure)[4]. These information highlights the need to address loss and damage due to climate-induced disasters in Sri Lanka across all sectors at all levels.

Sri Lanka has launched the NDC implementation roadmap for 2021-2030 demonstrating its commitments to reduce greenhouse gas emissions. The country has also launched the Climate Prosperity Plan (CPP) in 2022, a roadmap to attract foreign investment to boost economic growth and employment while accelerating climate adaptation and transitioning towards a low-carbon economy. Sri Lanka is currently developing the Carbon Net Zero Road Map and Strategic Plan to address the alarming situation of climate change. Further, the National Climate Change Act of Sri Lanka is being drafted to provide the regulatory support to implement the National Policy on Climate Change.

Moreover, climate-related opportunities are enormous, such as improving resource efficiencies and cost savings, adopting low-emission energy sources, developing new products and services, accessing new markets, and building resilience along the supply chain. Further, Green Taxonomy of Sri Lanka and the proposed Green Bond Framework provides a standardized set of criteria and guidelines that define and categorize environmentally sustainable and climate-friendly activities, ensuring transparency and credibility in green finance, while facilitating the identification and promotion of green investments and projects within the country.

[3] MNPEA (2017): Post Disaster Recovery Plan Sri Lanka floods and Landslides, Ministry of National Policies and Economic Affairs, and Ministry of Disaster Management, 2017

[4] WB (2018): Contingent Liabilities from Natural Disasters Sri Lanka, World Bank

(ii) The Need

Sri Lanka requires a significant update of the National Climate Change Policy adopted in 2012 to address climate vulnerability, national priorities, new and emerging global developments, and benefit from climate-related programmes, mechanisms and funding. The updated policy will not be a stand- alone guiding document but be implemented in coherence with other national policies adopted by the country through strong inter-institutional coordination and with the active engagement of all stakeholders.

(iii) Purpose and Context

The updated National Policy on Climate Change (NPCC) addresses the gaps identified in relation to mitigation, adaptation, loss and damage, andclimate financing that hinders planning, implementation and monitoring of Nationally Determined Contributions (NDCs) and the National Adaptation Plan (NAP) for Climate Change Impacts at national level, and be compliant with the National Environment Policy of Sri Lanka adopted in 2022, Paris Agreement (PA) and United Nations Framework Convention on Climate Change (UNFCCC). The updated policy is guided by the changes in processes, practices, and structures and adjustments in ecological, social or economic systems. It also focusses on the complex interactions between climate risks and socio-economic factors, while minimizing the vulnerability or improving the resilience of sectors and communities of SriLanka. The policy sets the platform and facilitates implementation of climate actions in Sri Lanka in a holistic matter integrated into a broader environmental context, building synergies with other policy instruments adopted in the country and ensuring effective resource mobilization.

(iv) Rationale

The government of Sri Lanka recognizes the importance of addressing climate change that threatens all economic sectors, ecosystems and people of the country. The NPCC, as a central policy instrument, will help protect the development priorities of Sri Lanka from climate-induced risks, and would serve as the anchor for the country's response to the commitments to the PA and UNFCCC. In this context, the NPCC encompasses reducing greenhouse gas emissions (mitigation), adaptation to climate change, addressing climate-induced loss and damage, investments and access to climate finance, benefit sharing of climate actions, etc. The NPCC would thus, create and support the mandate for the national and provincial adaptation process to build climate resilience and to implement the low emission pathway of development of Sri Lanka aiming at carbon neutrality by 2050, integrating into the broader context of national economic policies while ensuring sustainable development.

2) Policy Vision, Mission and Guiding Principles

The vision, mission and the guiding principles providing the direction for the NPCC are given below:

Vision

A climate-resilient low-carbon prosperous Sri Lanka

Mission

Implement climate action for a low-carbon future with smart adaptive measures to minimize the negative impacts of climate change ensuring sustainable development of the country while contributing to global efforts in reducing greenhouse gas emissions.

Guiding Principles

(1) Sustainability will be maintained through integrating climate strategies and actions that reduce vulnerabilities, build resilience and minimize greenhouse gas (GHG) emissions.

(2) Shared responsibility of all citizens in addressing climate change-induced issues will be ensured while incorporating youth, children vulnerable groups including women, for the decision-making process in climate actions at all levels.

(3) Climate mitigation (GHG emission reduction) and adaptation will be ensured.

(4) Precautionary principles will be followed in the absence of science-based evidence in decision-making.

(5) Climate financing network for blue – green economic initiatives will be ensured and innovative and a blend of financial instruments and partnerships help will be promoted in meeting the incremental costs of climate actions).

(6) Principles of circular economy prevails and adopted in relation toclimate change.

(7) Poverty eradication and sustainable human development initiatives implemented while ensuring Ecosystem stability.

(8) Unsustainable consumption and production lead to GHG emissions and create and/or aggravate climate change.

(9) Interconnected nature of climate change and its relationships with diverse sectors will be recognized and coordination and consistency among climate efforts will be promoted.

(10) Implementation of transformative, transparent, inclusive, andparticipatory governance will be achieved through social and gender equity and equality, to lead to the creation of effectiveand long-lasting climate-resilient societies.

(11) Innovative and a blend of financial instruments and partnerships help to meet the incremental costs of climate actions.

3) Policy Statements

(a) Governance and Regulatory

(1) Climate actions are integrated to the development agenda.

(2) Legal and regulatory frameworks to tackle climate change and environment sustainability are constituted.

(3) Climate sensitivity of the nation is enhanced through developing resilience and adaptive capacity.

(b) Climate Vulnerability

(4) Climate-induced risks are reduced.

(5) National-level collaboration, Co-operation, coordination, and partnerships in climate action is assured.

(c) Reducing Greenhouse Gas emissions

(6) Greenhouse gas emissions reduced, and Net Zero Economy ensured.

(7) Market and non-market-based instruments for climate actionsare adopted.

(d) Climate Adaptation

(8) Sustainable management of natural resources, biological diversity and ecosystem services is ensured.

(9) Food security and poverty alleviation are addressed.

(10) Human and environmental health are improved.

(e) Climate Investment and Financing

(11) Investments in research and development in climate actions are secured.

(12) Financing and resource mobilization for climate action are assured.

(13) Develop mechanisms to access international climate finance.

(f) Technology Development and Transfer, and Climate Information Management

(14) Development of effective climate-technology, transfer, and adoption are ensured.

(15) Effective management, sharing and the use of climate data andinformation are ensured.

(g) Cross-cutting

(16) Sustainable Development achieved through climate change adaptation and mitigation.

(17) International collaboration and cooperation for climate actionare assured.

(18) Just transition is adopted as an approach to reach a carbon-neutral economy.

(19) Loss and damage impact due to climate change are addressed.

4) Policy Goals and Objectives

Goals

(1) Climate resilience improved through policies, legislation, and governance.

(2) Align climate actions with national priorities supported by decision-making and implementation atall levels.

(3) Resilient generations empowered to engage in implementing climate actions to achieve sustainable development in Sri Lanka.

(4) Resilient livelihood assured food security, and poverty alleviation through implementing climate actions.

(5) Ecosystems stability ensured through implementing climate actions in management, conservation and sustainable utilization of ecosystems and ecosystem services.

(6) Carbon neutrality achieved by 2050 through GHG emission reduction and carbon sequestration.

(7) Climate – literality among all citizens enhanced with understanding on required climate induced disaster risk reduction and low carbon behaviors to reduce climate change impacts.

(8) Weather and climate early warning systems established with a reasonable lead time and a finer spatial resolution.

(9) Sustainable financing ensured through developing mechanisms to access international climate finance.

Policy Objectives

(1) To mainstream and integrate resilience-building and GHG emission reductions in all sectoral policies and programmes at all levels.

(2) To develop and enforce a legal framework to ensure effective implementation of the policy and climate action.

(3) To integrate laws and policies on adaptation and climate-induced disaster risk reduction towards climate-resilient national development.

(4) To create awareness on the multifaceted issues of climate change and empower communities, especially women, youth and children, on their roles and responsibilities as agents of change in implementing climate action.

(5) To develop human and institutional capacities to implement climate actions at all levels.

(6) To meet national commitments on climate change for the benefit of the nation

(7) To mobilize climate finance to support the implementation of climate action in compliance with the multilateral environment agreements (MEAs) signed by the country.

(8) To support carbon trading and other market- and non-market mechanisms to reduce GHG emissions.

(9) To develop synchronized and seamless early warning systems for social and sectoral protection and resilience.

(10) To engage private sector and business community to actively invest and participate in climate actions.

(11) To utilize more financial and economic opportunities of the blue-green economy to ensure sustainable socio-economic development.

5) Applicability and Scope

This NPCC is an overarching and a cross-cutting policy, addressing issuesrelated to climate change faced by all sectors, and at all levels. The policy ensures the concept of “Leave no one behind”. The line Ministries and Departments/agencies are expected to translate the policy and strategic guidance provided, into their actions. The National Climate Change Act which is currently being developed will provide regulatory strength to implementation of the policy. The NPCC does not only looks at climate change and its impact on the well-being of the people of Sri Lanka and its environment but also paves the way towards resilient building and achieving carbon neutrality by 2050.

6) Policy Implementation

The Ministry in charge of the subject of Environment of the Government of Sri Lanka will guide the implementation of the policy with the support of line Ministries and Departments/agencies in close coordination with the Climate Change Office of the Presidential Secretariat. Matters on Climate Financing will be led by the Ministry of Finance in close coordination with the relevant Ministries/Departmentsand Agencies. Conventions and international negotiations will be spearheaded by the Ministry of Foreign Affairs

The coordinating structure of the NDCs and NAP at national and provincial levels will be utilized in timely and effective implementation of the NPCC across all sectors at all levels. The Climate Change Secretariat (CCS) of the Ministry of Environment will coordinate and facilitate climate action in collaboration with the line Ministries and will seek technical guidance from National Expert Committees on Climate Change Adaptation (NECCCA) and Mitigation (NECCCM) for formulationand inclusion of activities into adaptation and mitigation plans, and integration of the NPCC into sectoral policies.

7) Monitoring and Evaluation

Effective implementation of the National Policy on Climate Change will be ensured though a monitoring mechanism. The strategies under the policy statements are linked to broader sets of indicators and aligned with existingand revised action plans. The overall responsibility of ensuring the implementation of the policy lies with the MoE. However, matters pertainingto climate finance will be monitored by the Ministry of Finance. Since climatechange is not a stand-alone subject, but that which has intra and inter connections with other subjects/ sectors, the MoE plays the role of mainly acoordinator / facilitator. The MoE ensures that the strategies listed under the policy statements are integrated into action plans of sectoral development plans. These are also integrated through existing NEAP, NDC, NAP’s and future PAPs which have their own /respective KPIs and Monitoring and Evaluation mechanisms.

Therefore, the overall progress of the policy implementation will be reportedat the Inter-Agency Coordinating Committee on Climate Change establishedby the Ministry of Environment. Further, climate actions in the Roadmap of Carbon Net Zero 2050 and Strategic Plan will be monitored by a committee established specifically for measurement, reporting and verification (MRV) /M&E purposes.

8. Strategies

The 135 Strategic actions identified under 19 policy statements are given below with responsible agencies for implementation:

Policy Statement	Strategies	Responsible Agencies
GOVERNANCE AND REGULATORY		
1. Climate actions are integrated to the development agenda	1.1. Perform periodic assessments of climate impacts in relation to economic and non-economic measures to build resilience at all levels.	MoE, Academia
	1.2. Integrate climate change adaptation and climate-induced disaster risk reduction laws and policies towards a climate-resilient national development.	DMC, MoDM, MoE, NBRO
	1.3 Develop and periodically update GHG inventories for all sectors in NDCs identified to reduced GHG emissions.	MoE
	1.4 Empower relevant officers in all sectors across all levels to enable decision-making based on potential climate impacts, including pathways of GHG emission reductions in deciding on development projects.	MoE
	1.5 Improve measurement, reporting, and verification (MRV) systems for climate actions in compliance with national and international mechanisms.	MoE
	1.6 Evaluate and report performance of climate action periodically to enhance confidence and promote timely action of all the stakeholders including citizens in the country.	MoE
	1.7 Provide adequate funds from internal and external sources for climate action and resilience building among institutions and communities.	MoF
	1.8 Respect and protect the rights of all people including specifically vulnerable groups in climate actions.	MoWCSD, MoE
2. Legal and regulatory frameworks to tackle	2.1. Strengthen legal and regulatory mechanisms to take adequate measures to implement climate actions at national and provincial levels.	MoE, MOF, MoPAHA &LG

climate and environment sustainability are constituted	2.2. Strengthen national institutional capacity at all levels to work in harmony with the environment- related rules and regulations of the country.	MoE, CEA, NPD, MoPAHA&LG, MoF
	2.3. Extend the advocacy programmes for active citizen engagement in identifying, assessing, and reporting climate/environmental crimes as per the existing National Environmental Act.	MoE, CEA
	2.4. Strengthen institutional and regulatory frameworks and infrastructure with legal enforcement and sound monitoring mechanisms for low-emission development planning and implementation.	MoE, MoP&E , NPD
	2.5. Develop statutory mechanisms to enforce the Provincial Adaptation Plans ideally with vested statutory power in the provincial governments and standard by-laws at local governments.	PC, LAs, MoE, MoPAHA&LG
3. Climate sensitivity of the nation is enhanced through developing resilience and adaptive capacity	3.1. Promote appropriate climate-sensitive behavioral changes with proactive and responsible participation of all relevant stakeholders for environment-friendly lifestyles and practices in sustainable development.	MoE, MoEd
	3.2. Strengthen and promote eco-friendly practices, including public procurement, in accordance with national policies and climate-smart priorities among public and private sectors.	MoF, MoE, CoC
	3.3. Enhance climate communication and facilitate the availability, accessibility, and sharing of innovative and reliable climate-smart technologies and best practices across all levels.	ICTA, MoA, MoE
	3.4. Build positive attitudes of different stakeholders at all levels to address multifaceted, current, and emerging climate change issues.	MoE, DMC, Academia
	3.5. Promote community-based coping mechanisms and development approaches emphasizing collective action to enhance the adaptive capacity of communities.	MoA, LA, MoE, DoA, DoF, DAP&H, MoWCSD, MoH, DoSS, NBRO
	3.6. Strengthen outreach of climate change awareness in non-formal education to ensure that vulnerable communities are not left behind.	MoEd, MoWCSD
	3.7. Develop sector-specific information and communication strategies to enhance climate adaptation, reduce GHG emissions and address loss & damage due to climate change in Sri Lanka.	MOE, MoD, MoA, MoFish, MoP&E, MoPAHA&LG,

		MoUD&H,MoT, MoI, MoIrr, MoH, MoTR, MoWS,NBRO
	3.8. Build awareness of climate change and its impacts, and climate actions across all strata of society through appropriate delivery mechanisms.	MoE, Academia
	3.9. Strengthen dialogue, coordination, coherence and synergies among relevant stakeholders on climate change, climate risks and impacts, and coping mechanisms.	MoE
	3.10 Formalize stakeholder engagement mechanisms for timely implementation of climate actions.	MoE
	3.11 Develop and inclusive and accountable governance mechanism for climate action, including an appropriate institutional mechanism, linking all stakeholders at all levels.	MoE, MoF,NPD,NPP,SDC, MoPAHA&LG
CLIMATE VULNERABILITY		
4. Climate-induced risks are reduced	4.1. Develop and adopt guidelines and mechanisms to reduce climate-induced risks and disasters to protect the communities, livelihoods, ecosystems, ecosystem services & their economic values, and natural and built environments across all levels.	MoDM, DMC, DoM, NBRO
	4.2. Develop and adopt emergency response and preparedness (ERP) plans with significant analysis of climate change forecast models to ensure preparedness against the challenges of extreme weather events.	MoDM, DMC, DoM, MoE
	4.3. Develop guidelines on displacement averting, minimizing and addressing non-economic losses due to climate change in the context of human mobility and livelihoods to increase the coping capacity by reducing national and regional climate-induced risks.	MoDM,DMC, , MoPAHA&LG, MoUD&H
	4.4. Improve coping capacity through reduction of national and regional climate-induced risks.	MoDM, DMC, NBRO
	4.5. Enhance knowledge and understanding of comprehensive risk management approaches among communities, particularly among children, youth and women, with necessary skills development mechanisms to address climate-induced risks.	MoWCSD, DMC, MoE, Academia

5. National-level collaboration, Co-operation, coordination, and partnerships in climate action is assured	5.1. Forge partnerships with relevant government agencies, research institutions, and local community organizations to leverage resources, expertise, and knowledge sharing in relation to climate change and climate action while ensuring accountability.	MoFA, MoSTR, NSF, MoE
	5.2. Strengthen national and local level climate adaptation planning and implementation capacity while ensuring future investments and economic plans are climate resilient.	MoUD&H, MoPAHA&LG
	5.3. Facilitate a robust consultative framework to underpin the periodic updating of the sectoral policy recommendations.	MoE, NPD
	5.4. Promote strategic partnerships and share data, information, and knowledge among stakeholders to address the multifaceted issues of climate change.	MoE, Academia
	5.5. Enhance inter-agency collaboration and emergency responses to protect and reduce risks to infrastructure from climate-induced hazards.	DMC, MoE
	5.6. Strengthen regional and international partnerships to enable financial and technical support for climate action.	MoF, MoFA, MoE
	5.7. Encourage synergy across various laws, regulations, programs, and thematic issues to efficiently use available resources for combating climate change.	MoJ, RSC
	5.8. Build partnerships between public, private, NGOs and CSOs to deliver the most effective and efficient climate change awareness campaigns at all levels.	MoJ, MoE, CoC
REDUCING GREENHOUSE GAS EMISSIONS		
6. Greenhouse gas emissions reduced and Net Zero Economy ensured	6.1. strength the capacity of industries and services to adapt to extreme weather events and encourage low carbon development at all levels at all levels.	MoE, MoI, BOI
	6.2. Enhance the usage of green, renewable and sustainable energy sources for all sectors and increase their generation, accessibility and affordability targeting carbon neutrality and adapting to climate change as identified in the Nationally-Determined Contributions of Sri Lanka.	MoP&E, MoE
	6.3. Develop and introduce economic incentives for less carbon-intensive fuels and energy-efficient technologies while imposing appropriate fiscal policies to discourage detrimental practices.	MoF, MoI

	6.4. Promote integrated low-emission mass transportation systems to improve fuel efficiency and air quality.	MoT, MoUD&H, UDA, RDA
	6.5. Promote non-motorized public transport modes and e-mobility.	MoT, RDA
	6.6. Encourage the use of appropriate, innovative, smart and energy conserving technologies or measures across all sectors.	MoSTR, MoI, MoPE, SLSEA
	6.7. Promote proactive behavioral changes by self-evaluation through green reporting systems to reduce GHG emissions at all sectors in all levels.	MoE, SLSDC , CEA
	6.8. Promote integrated waste management systems.	MoE, MoPAHA&LG, NSWMA, NSWMSC
	6.9. Promote the circular economy concept to minimize waste generation, emissions, and wastage of resources, and improve resource efficiency both in production and consumption.	MoE, MoI
7. Market and non-market- based instruments for climate actions are adopted	7.1. Promote market and non-market-based instruments appropriate to national conditions to reduce GHG emissions and improve adaptation measures.	CCS, MoF
	7.2. Introduce a carbon tax on any entity contributing to GHG emissions incurring an additional cost based on the amount of emissions.	MoF, IRD
	7.3. Impose obligations through non-monetary incentives for reducing or eliminating negative environmental externalities by polluters contributing to climate change.	MoE, MoI
	7.4. Develop and introduce an efficient emission trading system.	MoE,CCS, MoF
CLIMATE ADAPTATION		
8. Sustainable management of natural resources, biological diversity and ecosystem services is ensured	8.1. Develop and disseminate environment-friendly products, processes, and techniques to promote sustainable utilization of natural resources and biodiversity to minimize adverse impacts of climate change.	MoE, MoI, MoSTR, MoA, (NCPC), EPA
	8.2. Improve carbon storage capacity/carbon sequestration in forest management, while minimizing deforestation, considering the ecosystem services and their economic values provided by forests.	MoE, MoWL&FC FD, DWC, DAD
	8.3. Develop a national accounting mechanism for valuing natural capital and ecosystem services in Sri Lanka.	MoE, MoF,CEA SEPC

	8.4. Ensure environmental and ecological stability through conservation of biodiversity, including wildlife and genetic resources, rehabilitation and restoration of degraded terrestrial and marine eco-systems and habitats.	MoE, MoWL&FC, FD, DWC, BDS, MoFish, DFAR
	8.5. Promote nature-based/ecosystem-based solutions to empower the livelihoods, especially focusing on the poor, women, youth, and persons with disabilities.	MoE, MoRD, MoWCSD, MoS&YA,DoSS
	8.6. Improve watershed-, river basin- and groundwater management to reduce pollution and conserve natural resources.	MoIrri, DAD,MASL, MoWL&FC, MoWS
	8.7. Minimize the adverse impacts of climate change through variable seasonal rainfall, increasing ambient temperature and sea level rise on natural and manmade water bodies.	MoIrri, NWSDB, WRB, MoWS
	8.8. Strengthen the integrated water resources management, efficient water use, and water- sharing through climate-smart adaptive technologies and behavioral changes with the engagement of the community and coordination among relevant stakeholders.	MoWS, NWSDB, MoIrr
	8.9. Enhance climate resilience of the natural ecosystems and their diversity, ecosystem services and their economic values.	MoE, MoWL&FC,CEA, NBRO
	8.10. Incorporate measures to protect wetlands, coastal ecosystems, and urban biodiversity rich areas into infrastructure planning.	MoE, MoUD&H , MSS, CC&CRMD, MoWL&FC, SLLDC, NBRO
	8.11 Ensure Climate impact assessment is incorporated in to all environment related assessments.	MoE, MoUD&H , MSS, CC&CRMD, MoWL&FC, SLLDC, CEA
9. Food security and poverty alleviation are addressed	9.1. Enhance food availability, accessibility, affordability, stability and safety by using appropriate climate-smart technologies and timely dissemination of climate information.	MoA, DAPH
	9.2. Promote Climate-Smart Good Agricultural Practices (CS-GAP) and Climate Smart Good Animal Husbandry Practices (CS-GAHP) within the framework of sustainable development to enhance productivity.	MoA, DAPH, DoA

	9.3. Promote employing low carbon technologies in crop and animal production and value chain.	MoA, DoA, DAPH
	9.4. Return the benefits of carbon tax to support alleviation of poverty among the most vulnerable.	MoF
	9.5. Enhance resilience of actors across the value chain in the food system to extreme events to improve livelihoods and alleviation of poverty.	MoA, DMC, MoRD
	9.6. Promote Climate Smart Good Manufacturing Practices (CS-GMP) for crop and animal – based industries in the food system.	MoI, MoH, MoF,MoA
	9.7 Promote climate resilient livestock farming and agricultural practices and increase the use of resources efficiently and effectively.	MoA
	9.8 Promote the involvement of women in livestock and agriculture sector to ensure food security and alleviate poverty.	MoA, DoA, DAPH
10.Human and environmental health are improved	10.1. Recognize and take appropriate actions to safeguard health, biodiversity, humanity and the environment.	MoH, MoE,
	10.2. Promote monitoring of climate-induced occurrence and spread of diseases, and share related information between health agencies and other relevant sectors.	MoE, MoH
	10.3. Ensure integration and investment in climate-proofing in the design, development and maintenance of infrastructure and industry development.	MoI
	10.4. Develop measures to assess and retrofit the existing built Infrastructure for climate hazards to reduce health impacts arising due to climate change.	MoI, MoUD&H
	10.5. Ensure protection of health and environment from climate hazards.	MoH, MoE
	10.6 Climate related outbreaks of pests and invasive species monitored.	MoA, MoWL&FC,
	10.7. Support innovations for more climate-resilient construction techniques, building materials and services while ensuring resource optimization.	MoUD&H, MoI, NBRO
	10.8. Enhance access to information by the public regarding the impacts of climate change on human health for all ages, especially for children and elderly through real time data.	MoH, MoC
	10.9 Building a climate resilient low carbon health sector.	MoH, MoC

CLIMATE INVESTMENT AND FINANCING		
11. Investments in research and development in climate actions are secured	11.1. Promote interdisciplinary, multidisciplinary, and trans-disciplinary research and development and commercialization of research outputs aimed at assessing and addressing climate change issues and climate-smart technologies.	MoSTR, MoE, NBRO
	11.2. Encourage and support regional and international cooperation and networking to promote climate change research and green investments.	MoFA
	11.3. Facilitate dissemination of climate-related research findings among all stakeholders at national and local levels, in a transparent manner, through cooperation and networking.	MoEd, MoE
	11.4. Provide a conducive environment for innovations through research and development related to climate change, including the use of traditional and local knowledge.	MoSTR, MoI, NBRO
	11.5. Enhance the science-policy interface for evidence-based public policy decision-making and programme development.	MoSTR, MoI
12. Financing and resource mobilization for climate action are assured	12.1 Explore the possibility of structuring results-based payment instruments such as Development Impact Bonds for greater involvement of private, non-profit and financial sector actors on sustainability initiatives including climate and nature and education and health.	MoF, SEPC, CBSL
	12.2 Promote domestic resource mobilization for the implementation of climate actions identified under the NDCs.	MoF
	12.3. Develop, update and implement tools/mechanisms, including national climate action priorities, NDC and NAP implementation plans at national and provincial levels, 2050 Carbon Net Zero Roadmap and Strategic Plan, Climate Prosperity Plan, to encourage external donors and investors for programmatic approaches that build long-term capacity and resilience.	MoF, SEOC, MoE,
	12.4. Develop and strengthen close collaboration with global climate financing facilities such as the Green Climate Fund (GCF), Adaptation Fund (AF), Loss and Damage Fund (LDF), Global Environment Facility (GEF), multilateral donor agencies, and other development partners to support climate actions in Sri Lanka.	MoFA,ERD.MOE

	12.5. Develop mechanisms to establish, enhance, and improve skilled human resources and modern technological resources, especially to access and manage climate finances at all levels.	MoEd, MoHE,MoF
	12.6. Encourage the adoption of appropriate and innovative financial instruments to support climate action on adaptation, reducing GHG emissions, and addressing loss and damage due to climate change.	MoF,CBSL,FRA
	12.7. Engage and explore potential of creating a country-level blended finance facility for greater participation of stakeholders in resource mobilization (including international development finance and international and domestic private capital).	MoF, MoE
13. Develop mechanisms to access international climate finance	13.1 Support mapping of key international climate /green finance instruments	MoF, MoE
	13.2 Develop technical proposals to access finance for critical sector	MoF, MoE
	13.3 Support capacity development of selected agencies on Green Project evaluation and selection, fund allocation, progress reporting and impact reporting etc	MoF, MoE
	13.4 Constitute a Green Project Preparatory Fund under the General Treasury and develop guideline on utilization and replenishment of the fund.	MoF
TECHNOLOGY DEVELOPMENT AND TRANSFER, AND CLIMATE INFORMATION MANAGEMENT		
14. Development of effective climate technology, transfer, and adoption are ensured	14.1. Develop a mechanism/mechanism to identify technology needs periodically, and mobilize effective partnerships to fulfil the needs.	MoE, MoI,
	14.2. Develop and enhance skilled human resource base at all levels to absorb and adopt new technologies effectively and promote innovations locally.	MoEd,MoSTR,
	14.3. Facilitate technology transfer from other countries to support climate action in Sri Lanka.	MoFA,MoSTR,NRC, MoE
	14.4. Create an enabling environment to promote local innovators and develop climate smart technologies to reduce GHGs, adapt to climate change and minimize loss and damage due to climate change.	MoSTR, MoI, NSF
	14.5. Harness and patronize local technologies and traditional knowledge related to climate action, including early warning systems, ensuring vigilance against misappropriation.	MoC,MoSTR,MoIM

	14.6. Promote mechanisms to recognize and transfer, appropriate and gender-responsive climate technologies to vulnerable communities.	MoWCSD, MoCE,
	14.7. Mobilize social capital to invest in and facilitate participation of women, children and youth as agents of change to lead technological innovation and transformation required for climate actions.	MoWCSD,MoY&S, MoEd
15. Effective management, sharing, and use of climate data and information are ensured	15.1. Support transition to a modern nationwide climate observation, network its database system and maintain sound and robust data management operations to improve data accessibility, use and support forecasting and early warning systems.	MoE
	15.2. Promote the use of existing platforms such as the online portal on National Climate Change Data Sharing Network (NCC DSN) of Sri Lanka as an effective climate information collection and dissemination system to ensure informed decision-making and knowledge management.	MoE, ICTA
	15.3. Develop sector-specific data portals to support data sharing at all levels linked to NCC DSN for easy access and use.	MoA, MoP&E
	15.4. Develop sectoral strategic action plans to collect, disseminate and use the required knowledge among all stakeholders through formal/ non-formal education/ learning systems, institutes and platforms.	MoEd, MoP&D
	15.5. Facilitate the management of climate-induced disaster risk reduction at all levels with a strong institutional commitment for data and information sharing.	DMC, DoM, NBRO
CROSS-CUTTING		
16. Sustainable Development achieved through climate change adaptation and mitigation	16.1. Strengthen ecosystem management and restoration programmes in all sectors across the country with community participation.	MoE, DWC, MoWL&FC, MoA
	16.2. Develop and implement a comprehensive climate risk management framework in the development agenda of Sri Lanka to manage impacts of climate change along the entire spectrum of hazards.	MoDM, DMC, MoP&D, NBRO
	16.3. Promote Ecosystem-based adaptation (EbA) while ensuring conservation and sustainable use of natural resources and improve lives and livelihoods of people along the development path.	MoE,MoF, MoWL&FC

	16.4. Develop and adopt innovative mechanisms such as debt for climate swaps, to overcome debt distress and issues related to climate change in the path for sustainable development.	MoF, CoC
	16.5. Design and implement climate smart (CS) programmes such as CS cities, CR villages, and CS schools, to support sustainable development.	MoE,MoUD&H, MoEd, NBRO
	16.6. Design and adapt protective measures for important biogeochemical zones and critical habitats affected by the changing climate.	MoE, MoDM, MoWL&FC
	16.7. Integrate climate-induced disaster risk reduction in infrastructure development plans across all sectors.	DMC, MoUD&H, MoT, NBRO
17. International collaboration and cooperation for climate action are assured	17.1. Adopt measures to honor international obligations/commitments at all levels with the support of the international community.	MoFA
	17.2. Develop partnership between institutions in Sri Lanka with internationally renowned Universities, development partners including UN agencies, and other capacity building and financing entities to support implementation of climate actions in Sri Lanka.	MoEd, MoFA
	17.3. Strengthen international cooperation to design and implement mechanisms for sustainability in climate action at all levels.	MoFA, MOE
	17.4. Support demonstration and periodic review of the government commitments for climate action in collaboration with the international Universities, development partners including UN agencies, and climate financing institutions such as green climate fund (GCF).	MoF, MoE
	17.5. Develop and adopt mechanisms to educate the international communities of the Sri Lankan best practices, achievements and lessons learned with the expertise from of the Universities, other educational entities and development partners in Sri Lanka.	NAICC, MoFA
	17.6. Improve coordination and collaboration with countries in the region to minimize the impact of climate change on all ecosystems, ecosystem services and their economic values.	MoFA, MoE
	17.7. Promote capacity building and technological innovations at national and international levels through the establishment of an International Climate Change University.	MoE, MoEd
18. Just transition is adopted as an	18.1. Strengthen knowledge and skill development of the existing workforce to secure their employment and enhance employability in the new and emerging areas of finding climate solutions.	MoEd, ILO, MoL

approach to reach a carbon-neutral economy	18.2. Develop and adopt an inclusive and transparent planning process targeting a transformational system change for climate action while ensuring job security and adequate social protection for all.	MoP&D,MoSEW
	18.3. Promote identification and creation of decent, green jobs by increasing green investment ensuring social protection and green education from primary to tertiary levels.	MoL, MoEd, NAITA
	18.4. Enhance investments in sustainable and resilient public infrastructure and development of markets for goods and services relevant for green works.	MoI, MoTrad, CoC
	18.5. Respect the human rights of potentially affected groups in implementing Climate Action through appropriate due diligence procedures.	MoJ,NHRC
	18.6. Respect and recognize the polluter-pays principle and life cycle approach at all levels in climate change-related matters.	MoE,CoC, MoI
	18.7. Ensure equitable and inclusive climate actions to overcome social, economic, and political inequities, language barriers, and the needs of those impacted by climate change.	MoSW,MoGA
	18.8. Integrate climate adaptation and mitigation into national poverty reduction policies through improving existing social protection systems to cope with climate change consequences and shocks for the most vulnerable people in the society.	SW, NPD
19. Loss and damage impacts due to climate change are addressed	19.1. Develop and adopt mechanisms to estimate loss and damages caused by climate change- induced disasters.	MoE, DMC, MoF, NPD, MoDM
	19.2 Introduce an online sector-wise loss and damage (L&D) reporting system.	MoE, ICTA
	19.3. Develop and adopt measures to avert, minimize and address loss and damage attributable to climate change.	MoE, DMC
	19.4. Strengthen forecasting and early warning systems of extreme and slow-onset climate events.	DoM, DoI, NBRO, DMC
	19.5. Introduce mechanisms through international cooperation to achieve the fiscal flexibility to allocate resources to addressing loss and damage.	MoF
	19.6. Develop and adopt a post-disaster needs assessments for climate-induced disasters.	DMC, MoE, MoDM
	19.7. Support mobilization and allocation of funding through international climate financing mechanisms including the Loss & Damage Fund (LDF).	MoF, MoE

Glossary

- **Carbon sequestration:** The process of capturing and storing atmospheric carbon dioxide.
- **Children**: Young persons between infancy and puberty.
- **Climate Action**: The act to reduce or stop climate change and prevent permanent environmental damage.
- **Climate Adaptation:** Reducing vulnerability to the immediate and predicted impacts of climate change and increasing the capacity of countries and communities to be more resilient and to cope better, which means everything from better skills to more access to suitable finance to newer technology.
- **Climate Change**: The climate change attributed directly or indirectly to human activity that alters the composition of the global atmosphere and is in addition to natural climate variability observed over comparable periods. Following key words were also considered individually but collectively considered under "climate change".
- **Climate Communication:** Educating, informing, warning, persuading, mobilizing andsolving climate change related issues.
- **Climate Data Management**: The long-term, high-quality and reliable climate instrumental time series that are key information required in undertaking robust and consistent assessments in order to better understand, detect, predict and respond to global climate variability and change.
- **Climate Finance**: Local, national or transnational financing that seeks to support mitigation and adaptation actions that will address climate change.
- **Climate Mitigation and Reducing GHG emissions**: Human interventions to reduce the emissions of greenhouse gases (GHGs) by sources or enhance their removal from the atmosphere by "sinks". A "sink" refers to forests, vegetation or soils that can reabsorb CO_2. Carbon dioxide is the most significant contributing gas to the greenhouse effect. Since levels of greenhouse gases are currently rising steeply, leading to the most dramatic change in the atmosphere's composition, international action on mitigation is urgently required.

- **Climate Research**: The systematic investigation into and study of materials and sources in order to establish facts and reach new conclusions in relation to climate change.

- **Climate Resilience**: Making all regions, countries, cities, businesses, communities, and individuals thrive in the face of multiple risks, uncertainty and threats posed byclimate change.

- **Climate Vulnerability**: The degree to which a system is susceptible to and unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and the variation to which a system is exposed, its sensitivity, and adaptive capacity.

- **Climate-induced Human Health**: The complete state of physical, social, and mental well-being as influenced by climate change, and not limiting to the absence of illness, disease, or infirmity, is as vital a resource as water, food, or energy.

- **Climate-induced migration**: The forced movement of people or groups of people who, due to a sudden or progressive change in the environment that adversely affects their lives, leave their habitual homes, either temporarily or permanently, and whomove either within their country or abroad.

- **Climate-sensitive:** The global temperature rise following a doubling of CO2 concentration in the atmosphere compared to pre-industrial levels.

- **Climate-smart**: An approach to help the people managing different economic systems respond effectively to climate change.

- **Disaster Risks**: Disasters, both sudden and slow-onset, are caused by hydro- meteorological hazards are the most visible manifestation of climate change, causing more significant losses and/or damages. Disaster risk refers to the potential loss of life, injury, or destroyed or damaged assets that could occur to a system, society or a community in a specific period, determined probabilistically as a function of hazard, exposure, vulnerability and capacity. Changing weather patterns have led to drought conditions, flash floods, landslides, cyclones that fall under ‘hydro- meteorological disasters’, occurring with more frequency and higher intensity, placing development gains at higher risk due to the associated losses and damages.

Sri Lanka should confront hazards such as sea-level rise, salinization, desertificationwhich progress over more extended periods leading to severe consequences such as drop-in potable water, loss of agriculture and food production, loss of biodiversity and habitat.

- **Displacement**: Climate-induced displacement is one of the most devastating consequences of climate change. Due to climate change, refugees and internally displaced people (IDPs) are a climate emergency. Many people live in climate "hotspots", where they typically lack the resources to adapt to an increasingly hostile environment. Hence, there is a necessity to support and resist the increasing chances of displacement of people due to the climate crisis.

- **Drought**: a deficiency of precipitation over an extended period (usually a season ormore), resulting in a water shortage, leading to a wide range of environmental, social, and economic impacts.

- **Equitable Access**: Refers to that every person in the society having the same opportunity for being benefitted from the efforts to address climate change.

- **Extreme event**: A time and place in which weather, climate, or environmental conditions, such as temperature, precipitation, drought, or flooding, rank above a threshold value near the upper or lower ends of the range of historical measurements.

- **Floods**: The most frequent natural disaster occurs when an overflow of water usually submerges land. Floods are often caused by heavy rainfall, rapid snowmelt or a storm surge from a tropical cyclone or tsunami in coastal areas.

- **Forest Degradation**: The reduction in the capacity of a forest to produce ecosystemservices such as carbon storage and wood products as a result of anthropogenic andenvironmental changes.

- **Gender**: The characteristics of women, men, girls and boys that are socially constructed, including norms, behaviors and roles associated with being a woman, man, girl or boy, and relationships with each other. Gender dimensions of vulnerability to climate change result from differential access of men and women tothe social, financial, and environmental resources required for adaptation.

- **Greenhouse Gas Emission**: The atmospheric gases responsible for causing global warming and climate change are called greenhouse gases (GHGs). The major GHGs are carbon dioxide (CO2), methane (CH4) and nitrous oxide (N20). Less prevalent but very powerful, GHGs are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and Sulphur hexafluoride (SF6). The ultimate objective of the international commitments, including UNFCCC, is to stabilize atmospheric concentrations of greenhouse gases at a level that will prevent dangerous interference with the climate system.

- **Industry**: An economic activity concerned with the processing of raw materials andmanufacture of goods.

- **Just Transition**: The greening the economy as fair and inclusive to everyoneconcerned, creating decent work opportunities, and leaving no one behind.

- **Livelihood:** The means of securing necessities of life.

- **Loss and Damage**: The harms caused by anthropogenic climate change. Loss refers to those lost forever and cannot be brought back, such as human lives or species loss, while damages refer to those damaged but can be repaired or restored, such as roads or embankments.

- **Rights-based Approach**: Enabling users to identify and monitor the efforts and initiatives on tackling climate change meant to contribute to the achievement of human development.

- **Sea level rise**: An increase in the level of the world's seas and oceans due to the effects of global warming, and its impacts include erosion of beaches, inundation oflagoons and deltas, and flooding and loss of many marshes and wetlands.

- **Traditional Knowledge**: Refers to the knowledge, know-how, skills and practices in addressing climate change that are developed, sustained and passed on from generation to generation within a community, often forming part of its cultural or spiritual identity.

- **Women**: Refers to female human beings who, in general, experience greater risks, burdens, and impacts of climate change than male human beings. In many contexts, gender inequalities limit the control that women and girls have over decisions governing their lives, as well as their access to resources such as food, water, agricultural input, land, credit, energy, technology, education, health services, adequate housing, social protection and employment. As a result of those inequalities, women and girls are more likely to be exposed to disaster- induced risks and losses relating to their livelihoods, and they are less able to adapt to changes in climatic conditions.

- **Youth**: Refers to the world population between the ages of 10 to 24. Young people are victims of climate change and valuable contributors to climate action by being agents of change, entrepreneurs and innovators and helping scale up and accelerate climateaction.

Annex 1: Related Policies, Acts, Strategic/Action Plans

National Policies, Acts, and Strategic/Action Plans considered in development of the Updated National Policy on Climate Change (in alphabetical order)

1. Agrarian Development Amendment Act, No. 46 of 2011
2. Agricultural Insurance Law No. 27 of 1973
3. Animal Diseases Act, No. 59 of 1992
4. Animal Feed Act No. 15 of 1986
5. Animals Act No 46 of 1988
6. Coast Conservation Act, No. 49 of 2011
7. Coconut Research (Amendment) Act No. 53 of 1961
8. Colombo District (Low-lying Areas) Reclamation and Development Board (Amendment) Act, No. 52 of 1982
9. Constitution of Sri Lanka of 1978
10. Control of Pesticides Amendment Act No 6 of 1994
11. Crown Land Ordinance No. 8 of 1947
12. Draft National Policy on Transport in Sri Lanka (2009)
13. Environmental Assessment and Management Framework of Sri Lanka (2016)
14. Fauna and Flora Protection (Amendment) Act, No. 22 of 2009
15. Felling of Trees Control Amendment Act, No. 1 of 2000
16. Fisheries and Aquatic Resources (Amendment) Act, No. 35 of 2013
17. Flood Protection Ordinance No. 4 of 1924
18. Forest (Amendment) Act, No. 65 of 2009
19. Industrial Policy Framework (2006)
20. Irrigation Amendment Act, No. 13 of 1994
21. Land Development Ordinance No. 19 of 1935
22. Land Grants (Special Provisions) Act No. 43 of 1979
23. Land Reforms Act, No. 14 of 1974
24. Mahaweli Authority (Amendment) Act No. 59 of 1993

25. Mangrove - National Strategy and Action Plan 2009
26. Marine Pollution Protections Act, No. 59 of 1981
27. National Action Plan on Plastic Waste Management 2021-2030
28. National Adaptation Plan of Sri Lanka for Climate Change Impacts (2016-2025)
29. National Agricultural Research Policy and Strategy (2018-2028)
30. National Agriculture Policy (Draft) 2022
31. National Aquaculture Development Authority of Sri Lanka Act Number 53 of 1998
32. National Aquatic Resources Research and Development Agency Act, No. 54 of 1981
33. National Biodiversity Strategy and Action Plan (2016-2022)
34. National Climate Change Policy (2012)
35. National Disaster Management Policy - 2010
36. National Drinking Water Policy
37. National Drought Plan for Sri Lanka 2020
38. National Energy Policy (2019)
39. National Environmental (Amendment) Act, No. 56 of 1988
40. National Environmental Policy and Strategies (2022)
41. National Environment Action Plan (2022-2030)
42. National Export Strategy (2018-2022)
43. National Land Use Policy (2007)
44. National Livestock Breeding Policy (2010)
45. National Physical Planning Policy and the Plan 2017-2050
46. National Plantation Industry Policy Framework (2006)
47. National Policy and Strategy for Cleaner Production (2005)
48. National Policy and Strategy on Cleaner Production for Agriculture Sector (2012)
49. National Policy for Disaster Management
50. National Policy on Conservation and Sustainable Utilization of Mangrove Ecosystems in Sri Lanka
51. National Policy on Protection and Conservation of Water Sources,

their Catchments and Reservations in Sri Lanka (2014)
52. National Policy, Strategies and Institutional Framework for Water Resources Development, Conservation and Management (2019)
53. National Policy, Strategy and Action Plan for Invasive Alien Species Control in Sri Lanka (2016)
54. National Policy on Sustainable Consumption and Production for Sri Lanka (2019)
55. National Policy on Waste Management (2020)
56. National REDD+ Investment Framework and Action Plan (2015)
57. National Water Supply and Drainage Board Amendment Act no 13 of 1992
58. National Watershed Management Policy (2004)
59. National Wetland Policy and Strategy (2006)
60. National Wildlife Policy (2000)
61. Plant Protection Act No. 35 of 1999
62. Provincial Council Act, No 42 of 1987
63. Public Investment programme 2021-2024
64. Regulation for fertilizer Act No 68 of 1968
65. Requisitioning of land Act, No. 55 of 1961
66. Road Development Authority Act, No. 73 of 1981
67. Royal Botanic Gardens Act, No. 87of 1991
68. Rubber Master Plan 2017-2026
69. Rural water supply and Sanitation Sector (2001)
70. Seed Act, No. 22 of 2003
71. Soil Conservation (Amendment) Act No. 24 of 1996
72. Sri Lanka Forestry Sector Master Plan and National Forest Policy 1995
73. Sri Lanka National Agriculture Policy (2007)
74. Sri Lanka National Involuntary Resettlement Policy (2001)
75. Sri Lanka National Nutrition Policy (2010)
76. Sri Lanka Sustainable Development Act, No. 19 of 2017
77. State Agriculture Corporation Act No. 20 of 1980
78. Tea and rubber estates (Amendment) Act, No. 20 of 2005

79. Temple Lands (Compensation) Ordinance, No. 9 of 1950
80. The State Lands Ordinance, No. 8 of 1947
81. Updated Nationally Determined Contributions 2021
82. Urban Development Authority Act, No. 41 of 1988
83. Vistas of Prosperity and Splendor 2020
84. Water Resources Board Act, No. 26 of 1964

Annex 2: List of Abbreviations

BAU	Business-As-Usual
BDS	Biodiversity Secretariat
BOI	Board of Investment
C&HSs	Cities and Human Settlements
CBSL	Central Bank of Sri Lanka
CoC	Chamber of Commerce
CC&CRMD	Coast Conservation and Coastal Resources Management Department
CCC	Ceylon Chamber of Commerce
CCS	Climate Change Secretariat
CEA	Central Environment Authority
CEB	Ceylon Electricity Board
COP	Conference of Parties
CPC	Ceylon Petroleum Cooperation
CSA	Climate Smart Agriculture
DAD	Department of Agrarian Development
DAPH	Department of Animal Production and Health
DCS	Department of Census and Statistics
DFAR	Department of Fisheries and Aquatic Resources
DMC	Disaster Management Centre
DoA	Department of Agriculture
DoI&EC	Department of Imports and Exports Control
DoM	Department of Meteorology
DRR	Disaster Risk Reduction
DS	Divisional/District Secretariat
DSM	Demand Side Management
DWC	Department of Wildlife Conservation
EDB	Export Development Board
EE	Energy Efficiency
ERD	Department of External Resources

EVs	Electric Vehicles
FD	Forest Department
GAP	Good Agriculture Practices
GBCSL	Green Building Council of Sri Lanka
GCF	Green Climate Fund
GHG	Greenhouse Gas
GoSL	Government of Sri Lanka
GPP	Green Public Procurement
GSTC	Global Sustainable Tourism Council
ICTA	Information and Communication Technology Agency
ID	Department of Irrigation
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
IRD	Inland Revenue Department
IT	Information Technology
ITI	Industrial Technological Institute
IUCN	International Union for Conservation of Nature
KPIs	Key Performance Indicators
L&D	Loss and Damage
LAs	Local Authorities
LINDEL	Lanka Industrial Estates Limited
M&E	Monitoring and Evaluation
MASL	Mahaweli Authority of Sri Lanka
MCs	Municipal Councils
MoA	Ministry of Agriculture
MoD	Ministry of Defense
MoDM	Ministry of Disaster Management
MoE	Ministry of Environment
MoEd	Ministry of Education
MoF	Ministry of Finance
MoFA	Ministry of Foreign Affairs
MoFish	Ministry of Fisheries

MoH	Ministry of Health
MoI	Ministry of Industries
MoHE	Ministry of Higher Education
MoIrri	Ministry of Irrigation
MoJ	Ministry of Justice
MEPA	Marine Environment Protection Agency
MoP&E	Ministry of Power & Energy
MoPlant	Ministry of Plantation
MoRR&HRA	Ministry of Rehabilitation, Resettlement & Hindu Religious Affairs
MoSD&VT	Ministry of Skills Development and Vocational Training
MoS&YA	Ministry of Sports & Youth Affairs
MoSEW	Ministry of Social Empowerment and Welfare
MoTR	Ministry of Tourism
DoSS	Department of Social Services
MoSTR	Ministry of Science Technology and Research
MoT	Ministry of Transport
MoTrad	Ministry of Trade
MoPAHA&LG	Ministry of Public Administration, Home Affairs, & Local Government
MoUD&H	Ministry of Urban Development and Housing
MoWL&FC	Ministry of Wildlife and Forest Resources Conservation
MoWS	Ministry of Water Supply
MoWCSD	Ministry of Women, Child Affairs and Social Development
MRV	Measurement Reporting and Verification
MSMEs	Micro, Small and Medium Enterprises
MSS	Merchant Shipping Secretariat
MSW	Municipal Solid Waste
NAICC	National Agriculture Information and Communication

	Centre
NAQDA	National Aquaculture Development Authority
NaPID	National Policy for Industrial Development
NARA	National Aquatic Resources Research and Development Agency
NBD	Department of National Budget
NBRO	National Buildings Research Organization
NCPC	National Cleaner Production Centre
NDCs	Nationally Determined Contributions
NEAP	National Environmental Action Plan
NECCC	National Expert Committee on Climate Change
NGO	Non-Governmental Organization
NPCC	National Policy on Climate Change
NPD	Department of National Planning
NPP	National Physical Plan
NSC	National Steering Committee
NSF	National Science Foundation
NSWMSC	National Solid Waste Management Support Center
NSWMA	National Solid Waste Management Authority (WP)
NWSDB	National Water Supply and Drainage Board
O&M	Operation and Maintenance
Pas	Protected Areas
PDNA	Post Disaster Needs Assessment
PMC	Planning and Monitoring Committee
RDA	Road Development Authority
RE	Renewable Energy
SD&CC	State Development and Construction Corporation
SDGs	Sustainable Development Goals
SEC	Securities & Exchange Commission
SEPC	Socio Economics and Planning Centre
SLGAP	Sri Lanka Good Agriculture Practices
SLLDC	Sri Lanka Land Development Corporation

SLSDC	Sri Lanka Sustainable Development Council
SLSEA	Sri Lanka Sustainable Energy Authority
SLT	Sri Lanka Telecom
SMART	Specific, Measurable, Achievable, Relevant, and Time-bound
SME	Small and Medium Enterprises
SMIs	Small and Medium Industries
TRI	Tea Research Institute
UCs	Urban Councils
UDA	Urban Development Authority
UN	United Nations
UNDP-SGP	United Nations Development Project – Small Grants Programme
UNFCCC	United Nations Framework Convention on Climate Change
WM	Waste Management
WRB	Water Resources Board

Climate Change Secretariat

Ministry of Environment

"Sobadam Piyasa", 416/1/C
Robert Gunawardena Mawatha, Battaramulla.

9 786245 817375

Annex II

Expert Opinion

Prof. Buddhi Marambe
Faculty of Agriculture, University of Peradeniya, Sri Lanka

Climate justice is a moral right. The unprecedented nature of climate change has created ripple effects across all sectors of the economies in climate vulnerable countries like Sri Lanka, with deteriorating economic standards, social wellbeing and finally environmental sustainability. Sri Lanka is subjected to such climate devastations while contributing only 0.05% greenhouse gas (GHG) emissions with a per capita ratio of 0.88. In reality, the low-emitting countries like Sri Lanka are victims of the actions taken by high-emitting industrialized countries.

We are facing and will continue to face challenges emanating from the triple planetary crisis (TPC); climate change, biodiversity loss and environmental pollution. The TPC ignores geographical and administrative boundaries and has already hindered achieving Sustainable Development Goals (SDGs) and implementation of United Nations Framework Convention on Climate Change (UNFCCC) and its Paris Agreement (PA). To achieve the overall objectives of climate justice, and to support mitigation and adaptation initiatives of climate-vulnerable and developing countries, we need support from the industrialized/developing countries to the developing world that is hard-hit by the climate crisis. The developing countries should be relieved from their economic and debt burden to move along the pathway of green investments while easing the financial pressure. All in all, we all deserve the same quality of life and dignity as enjoyed by the developed countries.

The proposal and the launch of Climate Justice Forum (CJF) by the Government of Sri Lanka at the 28th Conference of Parties (COP28) of the UNFCCC no doubt provides a strong platform for all to ensure greater climate justice and accelerate financing of Loss & Damage L&D), while providing an alternate and non-traditional pathways to find solutions to the crisis. For example, the L&D caused by floods in May 2016 in Sri Lanka was to the tune of US$ 660 million, and that in May 2017 was estimated to be US$ 478 million. Moreover, the extreme rainfall event in May 2017, Sri Lanka lost 212 human lives and 78 recorded missing, where the losses cannot be valued in currency. We should build capacity to prepare ourselves to minimize damage caused, and cope with the disastrous consequences of climate change. It is heartening to see the youth has taken the leadership to fight for climate justice. We all demand actions to protect our future generations, which is indeed a moral responsibility and an obligation of every individual on this planet earth. Please refer to the research conducted by me and a few other scientists on the impact of climate change on the food security of Sri Lanka.

Climate, Climate Risk, and Food Security in Sri Lanka: Need for Strengthening Adaptation Strategies

Chapter · January 2015

DOI: 10.1007/978-3-642-38670-1_120

8 authors, including:

Buddhi Marambe
University of Peradeniya

Ranjith Punyawardena
Natural Resorce Management Center

Pradeepa Silva
University of Peradeniya

Sarath Premalal
Department of Meteorology, Sri lanka, Colombo

Climate, Climate Risk, and Food Security in Sri Lanka: The Need for Strengthening Adaptation Strategies

Buddhi Marambe, Ranjith Punyawardena, Pradeepa Silva, Sarath Premalal, Varuna Rathnabharathie, Bhathiya Kekulandala, Uday Nidumolu, and Mark Howden

Contents

B. Marambe (✉)
Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka
e-mail: bmarambe@pdn.ac.lk; bmarambe@yahoo.com

R. Punyawardena
Natural Resource Management Centre, Department of Agriculture, Peradeniya, Sri Lanka
e-mail: batugedara_vrp@yahoo.com

P. Silva
Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka
e-mail: pradeepas@pdn.ac.lk

S. Premalal
Department of Meteorology, Colombo, Sri Lanka
e-mail: spremalal@yahoo.com

V. Rathnabharathie • B. Kekulandala
Practical Action, Colombo, Sri Lanka
e-mail: varuna30@gmail.com; bkekulandala@gmail.com

U. Nidumolu
Ecosystem Sciences, Commonwealth Scientific and Industrial Research Organization (CSIRO), Canberra, Australia
e-mail: uday.nidumolu@csiro.au

M. Howden
Climate Adaptation Flagship, Commonwealth Scientific and Industrial Research Organization (CSIRO), Canberra, Australia
e-mail: mark.howden@csiro.au

W. Leal Filho (ed.), *Handbook of Climate Change Adaptation*,
DOI 10.1007/978-3-642-38670-1_120

Abstract

Climate is one of the main determinants of agricultural productivity in Sri Lanka. Of the major climatic parameters, temperature, rainfall, and humidity are of special significance, as these cause a substantial impact on the agricultural productivity of the country. Consequently, farming systems and agronomic practices in most agricultural regions of Sri Lanka have evolved in close harmony with the prevailing climatic conditions of respective climatic regions of the island. The overwhelming scientific research has provided evidence of two general trends in Sri Lankan climate, i.e., increasing ambient temperatures resulting in more heat stress, and more frequent and severe occurrence of extreme rainfall anomalies such as droughts and floods. Both of these conditions strongly affect the crop and animal production and thus the food security in the country. The National Climate Change Policy of Sri Lanka, which was adopted in 2012, clearly endorses the need of appropriate adaptation strategies to reduce the impacts on crop and animal production so as to ensure national-level food security. While some of the strategies and actions have already been implemented as an effort to address the emerging negative impacts of climate change, scope still exists for new entry points for adaptation with a view to reduce the climate vulnerability of the agricultural sector in Sri Lanka while increasing the resilience of the entire community. One example of these actions is the development of seasonal climate forecasts that could assist farmers, business across the value chain, and the policy makers to develop improved climate risk management strategies leading to ensuring food security.

This chapter provides a comprehensive overview of the climate and climate-related risks faced by the agriculture sector of Sri Lanka and highlights the need to strengthen adaptation options to ensure national-level food security.

Keywords
Climate risks • Crops and animals • Adaptation • Food security • Sri Lanka

Introduction

Sri Lanka is an island in the Indian Ocean located at the tip of the Indian subcontinent. The country has a total land area of 65,610 km^2 including 2,905 km^2 of inland water bodies. The maximum width from east to west is 240 km and the length in north-south direction is 435 km. Sri Lanka is located between 5°55–9°5′ North latitudes and 79°42–81°53′ East longitudes and hence has an equatorial climate. Extensive faulting and erosion over time have produced a wide range of topographical features with three distinguishable elevation zones within the island: the Central Highlands, the plains, and the coastal belt. In the south-central part of Sri Lanka, the rugged Central Highlands spans around 65 km in north-south direction with peak elevation at 2,524 m. The Central Highlands is the hydrological heart of the country as almost all major perennial rivers originate here, spreading radially from the highlands to the coast. Most of the island's surface consists of plains between 30 and 200 m above sea level. In the southwest, ridges and valleys rise gradually to merge with the Central Highlands, giving a dissected appearance to the plain. A coastal belt about 30 m above sea level consists of scenic sandy beaches indented by bays and lagoons.

Despite its relatively small extent, Sri Lankan landmass exemplifies a variety of climatic conditions. There are four important geographical and topographical features in Sri Lanka, which considerably influence the climate over the island, in particular the rainfall regime. The first is the fact that Sri Lanka is a small island situated in the warm tropical Indian Ocean with associated warm, humid air. The second is its proximity to the equator, which results in solar radiation rarely being a limitation to crop growth under general weather conditions of the island. The third is the existence of a large mass of hills at the center of the island, which is perpendicular to two approaching moisture-laden monsoon wind streams (the southwest monsoon in the middle of the calendar year and the northeast monsoon towards the end of the year). The fourth factor is the presence of a vast landmass of the Indian subcontinent to the immediate north and northwest of Sri Lanka, which has a large effect in driving the monsoon. These four factors directly or indirectly influence the rainfall regime of the island. In general, the climate of Sri Lanka is considered as tropical monsoonal with a marked seasonal variation of rainfall. Of the major climatic parameters, temperature, rainfall, humidity, and evaporation are of special significance to Sri Lankan agriculture, impacting substantially on the agricultural productivity of the country.

This chapter focuses on the general climate of Sri Lanka, climate-induced risk factors that influence agriculture production (considering both crop and animal production), and the relationship of these to the food security of the nation.

Rainfall

Rainfall in Sri Lanka has multiple origins. Monsoonal and convectional rainfall, and the formation of synoptic weather especially in the Bay of Bengal, account for the majority of the annual rainfall. The average annual rainfall of the island (Fig. 1) varies from about 900 mm at the southeastern part of the Dry Zone (*Maha Lewaya* at Hambantota) to over 5,500 mm on the southwestern slopes of the Central Highlands (Kenilworth Estate at Ginigathhena) (Punyawardena et al. 2013a).

The rainfall experienced during a 12-month period in Sri Lanka can be characterized into four rainfall seasons, namely, first inter-monsoon (March–April; FIM), southwest monsoon (May–September; SWM), second inter-monsoon (October–November; SIM), and northeast monsoon (December–February; NEM).

First Inter-monsoon Season (March–April)

Warm, humid, and uncomfortable conditions, with thunderstorm-type rain, particularly during the afternoon or evening, are the typical weather conditions during the first inter-monsoon (FIM) season. The distribution of rainfall during this period shows that the entire Southwestern sector of the hill country receives 250 mm of rainfall, with some localized areas on the Southwestern slopes experiencing rainfall in excess of 700 mm (e.g., 771 mm at the Keeragala Estate). Over most part of the island, the amount of rainfall varies between 100 and 250 mm, the notable exception being the Jaffna Peninsula in the Northern Province, which has lower rainfall in the FIM season (e.g., Jaffna, 78 mm; Elephant Pass, 83 mm; Fig. 2).

Southwest Monsoon Season (May–September)

Windy weather during the southwest monsoon (SWM) results in lower temperatures than those prevailed during the FIM season. The SWM rain totals vary from about 100 mm to over 3,000 mm (Fig. 3). The highest rainfall is received in the mid-elevations of the Western slopes (e.g., Ginigathhena, 3,267 mm; Watawala, 3,252 mm; Norton, 3,121 mm). Rainfall decreases rapidly from these maximum regions toward the higher elevation, as in Nuwara Eliya, it drops to 853 mm. The lowest rainfall is recorded from the Northern and Southeastern regions.

Second Inter-monsoon Season (October–November)

The second inter-monsoon (SIM) season is characterized by convective weather systems that typically generate thunderstorm-type of rain, particularly during the afternoon or evening (Fig. 4). However, unlike in the FIM season, the influence of weather systems such as low-level atmospheric disturbances, depressions, and

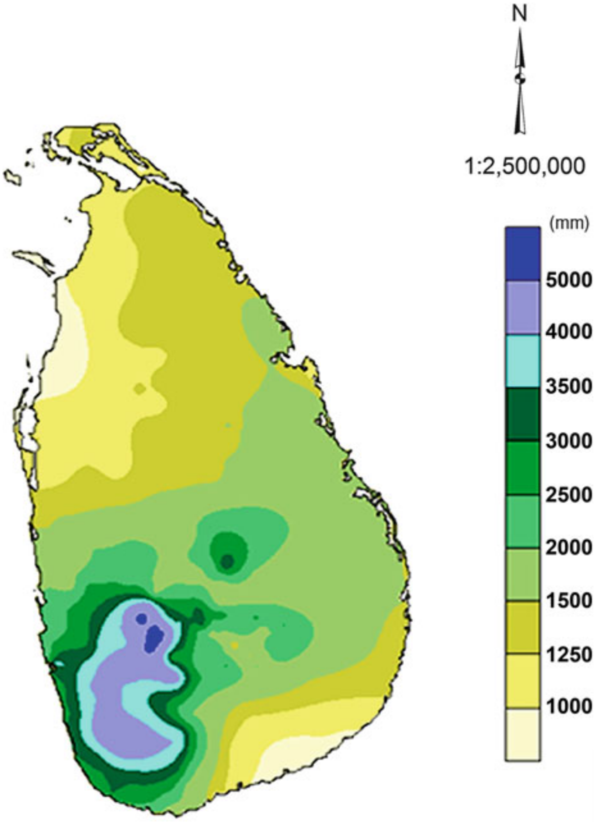


Fig. 1 Spatial distribution of the average annual rainfall in Sri Lanka (Source: Department of Meteorology, Sri Lanka)

cyclonic storms in the Bay of Bengal are common during this period. Under such conditions, the whole country can experience strong winds with a widespread, intense rain, which could lead to floods and landslides. The SIM period of October–November experiences the most evenly geographic distribution of rainfall in Sri Lanka. Almost the entire island receives in excess of 400 mm of rain during this season, with Southwestern slopes receiving higher rainfall in the range 750–1,200 mm (e.g., Weweltalawa, 1,219 mm).

Northeast Monsoon Season (December–February)

The dry and cold wind blowing from the Indian landmass will result in a comparatively cool but dry weather over many parts of Sri Lanka during the northeast monsoon (NEM) season, creating a pleasant and comfortable weather except for some rather cold morning hours in January. Cloud-free skies in January often provide days full of sunshine and pleasant and cool nights. During the NEM period, the highest rainfall amounts are recorded in the Eastern slopes of the Knuckles Range of the central hills (Fig. 5). The maximum rainfall is experienced at the

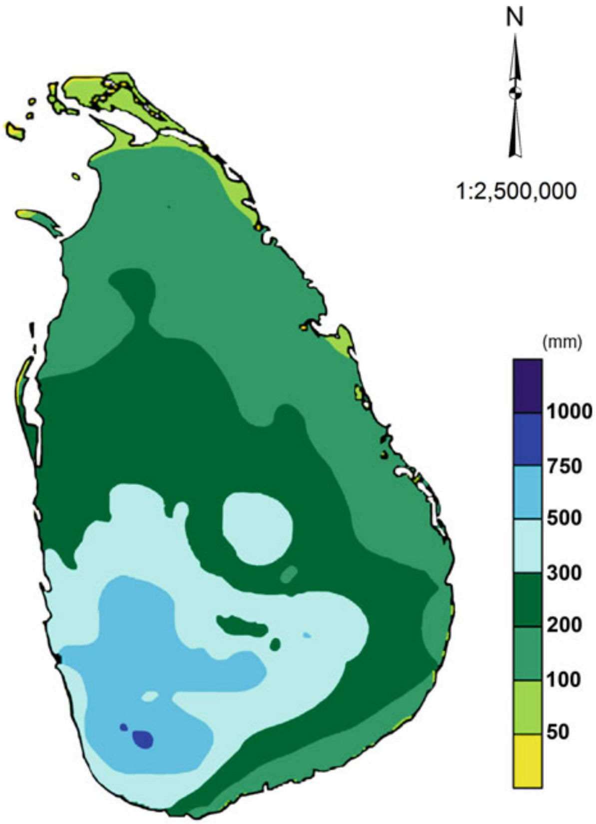


Fig. 2 Spatial distribution of the average rainfall in the first inter-monsoon in Sri Lanka (Source: Department of Meteorology, Sri Lanka)

Koboneela estate (1,281 mm), and the minimum is in the Western coastal area around Puttalam (e.g., Chilaw, 177 mm) during this period. There can be high interannual variability.

As depicted in Figs. 2, 3, 4, and 5, the four rainfall seasons do not bring homogeneous rainfall regimes over the whole island, thus leading to a high agro-ecological diversity in the country despite its relatively small extent. Out of the four rainfall seasons, two consecutive rainy seasons make up the major growing seasons of Sri Lanka, namely, *Yala* and *Maha* seasons. Generally, *Yala* season is the combination of FIM and SWM rains. As SWM rains are the highest over the country's Southwestern sector, the length (effectiveness) of this season in the rest of the country is generally confined only to 2 months (mid-March to early May), and hence, the *Yala* season is considered as the minor growing season of the country. The major growing season of the island, i.e., *Maha* season, begins with the arrival of SIM rains in October and continues up to late January/February with the NEM rains. Being mainly convective in nature, rains during the two inter-monsoon periods are usually associated with thunder and lightning along with short-duration high-intensity rains, especially during the FIM period.

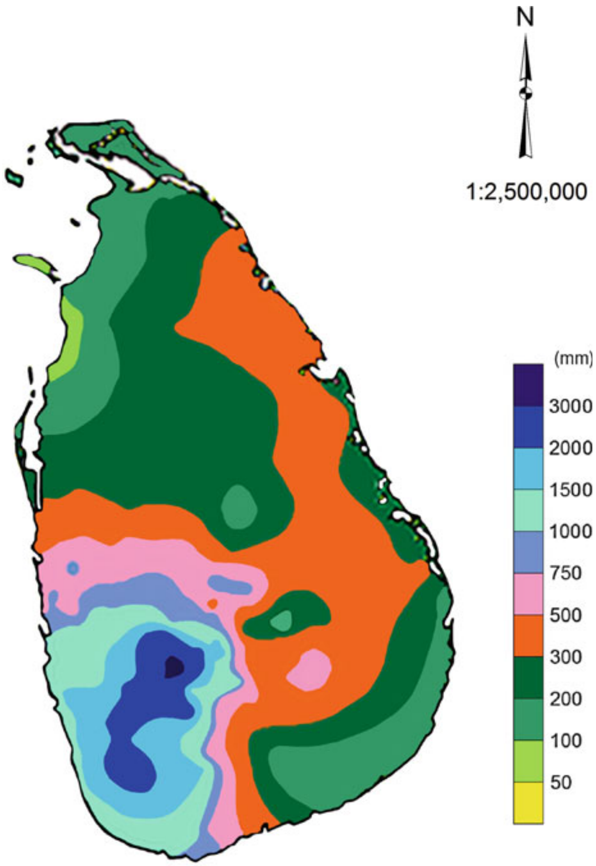


Fig. 3 Spatial distribution of the average rainfall in the southwest monsoon in Sri Lanka (Source: Department of Meteorology, Sri Lanka)

Temperature

The mean annual temperature in Sri Lanka manifests largely homogeneous temperatures in the lowlands and rapidly decreasing temperatures in the highlands. In the lowlands, up to an altitude of 100–150 m, the mean annual average temperature is 27 °C. In the highlands, the temperature falls quickly as the altitude increases. The mean annual temperature of Nuwara Eliya at an altitude of about 1,800 m is 15 °C. However, during the period of January to mid-February, the diurnal temperature variation around Nuwara Eliya is large, and thus, ground frost can be observed for about 3–7 days early in the mornings or nights when the temperature closer to the ground falls below the freezing point. However, during the period of May to September, if the westerly winds are strong, the leeward area in the east of the Central Highlands and the relatively flat terrain extending to the east coast experience warm, dry, and gusty winds. Such foehn-like winds are locally known as the *Kachchan* or *Yal-hulang*. In foehn conditions, the relative humidity

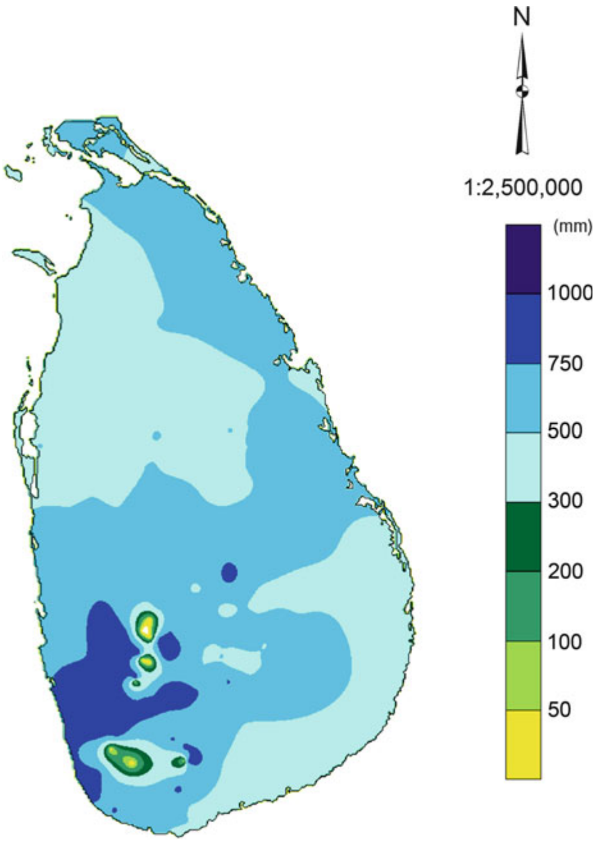


Fig. 4 Spatial distribution of the average in rainfall in the second inter-monsoon in Sri Lanka (Source: Department of Meteorology, Sri Lanka)

may fall to less than 50 %, causing vegetation and soil to dry out with possible bushfire disasters in Badulla and Moneragala districts. The coldest month with respect to the mean monthly temperature is January and the warmest months are April and August.

Relative Humidity

The relative humidity (RH) in Sri Lanka generally ranges from 70–90 % during mornings to 55–80 % during late afternoons depending on the geographical location. Relatively low humidity values (from 40–60 %) are reported in dry lowlands during June to August where the foehn-like wind (*Kachchan* wind) is often prominent. Comparatively high humidity condition that prevails during winter months (December to January) is one of the predisposing factors for plant disease outbreaks during the *Maha* season.

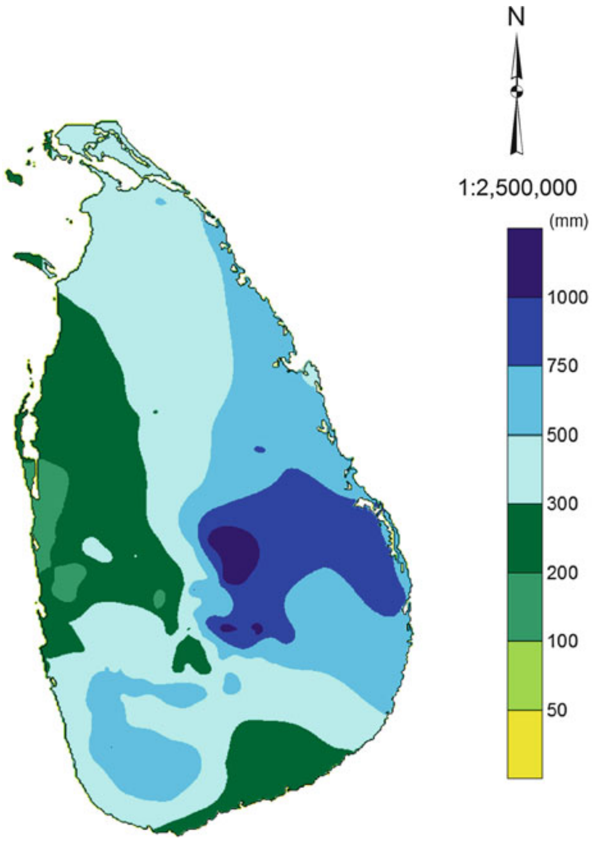


Fig. 5 Spatial distribution of the average rainfall in the northeast monsoon in Sri Lanka (Source: Department of Meteorology, Sri Lanka)

Evaporation

During the *Yala* season, pan evaporation is likely to range between 3 and 8 mm per day depending on geographical region. Higher values over 7 mm per day are often experienced in the dry lowland areas during this period. Meanwhile, a range of 2–5 mm per day is generally observed during the *Maha* season across different localities of the island.

Climatic Zones of Sri Lanka

Sri Lanka has traditionally been generalized into three climatic zones, namely, "Wet Zone" in the Southwestern region including central hill country, "Dry Zone" covering predominantly the Northern and Eastern parts of the country, and "Intermediate Zone," skirting the central hills except in the South and the West (Fig. 6).

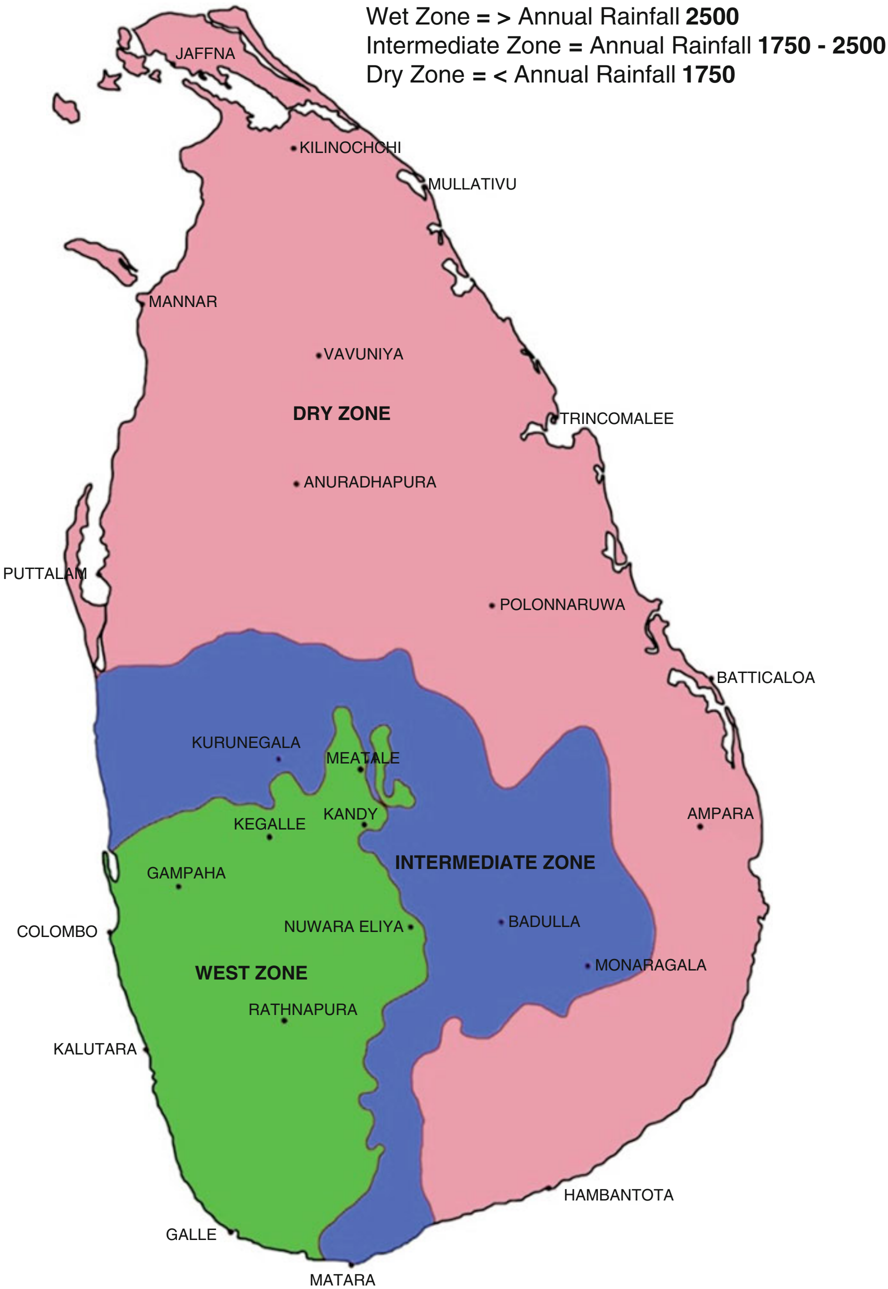


Fig. 6 Climate zones of Sri Lanka (Source: Punyawardena 2007)

In differentiating these three climatic zones, annual rainfall, contribution of southwest monsoon rains, soil type, land use, and vegetation have been widely used (Punyawardena 2007). The Wet Zone receives a relatively high mean annual rainfall over 2,500 mm without pronounced dry periods. The Dry Zone receives a mean annual rainfall of less than 1,750 mm with a distinct dry season from May to September. The Intermediate Zone receives a mean annual rainfall between 1,750 and 2,500 mm with a short and less prominent dry season. Sri Lanka has been further divided into 46 agroecological regions (Punyawardena 2007) that take into account the monthly rainfall amount (at 75 % probability) and distribution in addition to the parameters considered for identifying climate zones.

Climate Change in Sri Lanka

Sri Lanka possesses a long series of historical climatic data, especially rainfall and temperature records, which started from the 1860s in some locations. A recent analysis of these data has shown that the country's average temperature is significantly increasing at a rate of 0.01–0.03 °C per year (Fernando and Chandrapala 1995; Nissanka et al. 2011; Premalal and Punyawardena 2013). The increase is more pronounced in nighttime minimum temperature than that of the daytime maximum temperature (Marambe et al. 2012). However, due to high interannual variability, there are no discernible significant trends in seasonal and annual rainfall (Nissanka et al. 2011; Marambe et al. 2012), except a few locations among over 400 rain gauging stations of the country as has been found in many other locations across the globe. The same is true in terms of variability of cumulative and seasonal rainfall. However, it was evident that variability of seasonal rainfall during the most recent decade (2001–2010) has increased compared to the previous decade (1991–2000) in most places of the island across all three climatic zones with occurrence of more frequent drought and flood conditions.

A recent study focused on the occurrence of extreme positive rainfall anomalies in the central hills of the country has shown that in contrary to common belief, there is no significant increase of "heavy and very heavy" events in the region (daily rainfall values that exceeded the 95th and 99th percentile values, respectively, in each station from 1961 to 2010), but an apparent increase of such events during the period of 2006–2010 has been evident (Punyawardena and Premalal 2013). The temperature and rainfall projections in Sri Lanka under A2 and B2 scenarios using ECHAM4 general circulation model (GCM) for downscaling have revealed that the average annual temperature of Sri Lanka will increase with a range of 2.5–4.5 °C by the year 2080 under the A2 scenario and with a possible average annual temperature increase of 2.5–3.25 °C under the B2 scenario (Punyawardena et al. 2013a). Both these projections are analogous with the IPCC global projections of temperature changes at the turn of the century. In terms of the future rainfall climatology of Sri Lanka, projections with A2 scenario have revealed that Dry Zone will become drier while Wet and Intermediate Zones may become wetter than at present. In recent studies carried out in Sri Lanka, Marambe et al. (2012) and

Premalal and Punyawardena (2013) reported that climate change may be manifesting in changed conditions of the monsoons, with change in the date of onset and high variability, resulting in drier dry areas and wetter wet areas. Meanwhile, the B2 scenario uncovers a relatively complex situation of both Dry Zone and the Central Highlands of Sri Lanka to become drier than today as time progresses while the wetter parts of Sri Lanka to become further wet but at a lesser rate compared to the A2 scenario (Punyawardena et al. 2013b).

Vulnerability of Sri Lanka to Climate Change

Climate change is a cross-cutting issue and it is increasingly recognized as a necessary component of development-oriented decision-making process. In order for development investments to become resilient to anticipated climate change, it is important to understand the nature of vulnerability from a subnational perspective and reflect this variance in development strategies that are formulated at different administrative levels such as province, district, and divisional secretariat (DS) levels.

Punyawardena et al. (2013a), using 22 physical and socioeconomic parameters, which directly related to all three components of climate change vulnerability, namely, exposure, sensitivity, and adaptive capacity, have revealed that spatial variations of vulnerability of Sri Lanka to climate change varies according to socioeconomic, environmental, and institutional conditions of respective administrative districts in ways that do not necessarily follow the most exposed and geographically sensitive districts (Fig. 7).

The urban areas in the low-country Wet Zone except Ratnapura district are by far the least vulnerable to climate change in Sri Lanka, despite some exposure to climatic hazards such as floods. Communities in the Northern Province (excluding Jaffna Peninsula) and Puttalam and Ratnapura districts are confronted with very high degree of vulnerability due to high exposure, high sensitivity of livelihoods, and lower socioeconomic development. The major rice-producing districts of the island, namely, Anuradhapura, Polonnaruwa, Batticaloa, Hambantota, Monaragala, and Kurunegala (Trincomalee and Ampara in the Eastern Province are the exceptions), are located in the Dry and Intermediate Zones and are highly vulnerable to climate change. The mountainous districts of the Western and Eastern flanks of the central hills of Sri Lanka, namely, Kandy, Matale, Nuwara Eliya, and Badulla, along with Trincomalee and Ampara districts in the Eastern Province, show a moderate degree of vulnerability to climate change.

Food Security in Sri Lanka: Present Status

Food security (FAO 2009) in Sri Lanka is determined by several factors including diverse food systems and farming systems. Food systems in Sri Lanka are affected to different degrees by natural disasters induced by the climate change with a larger

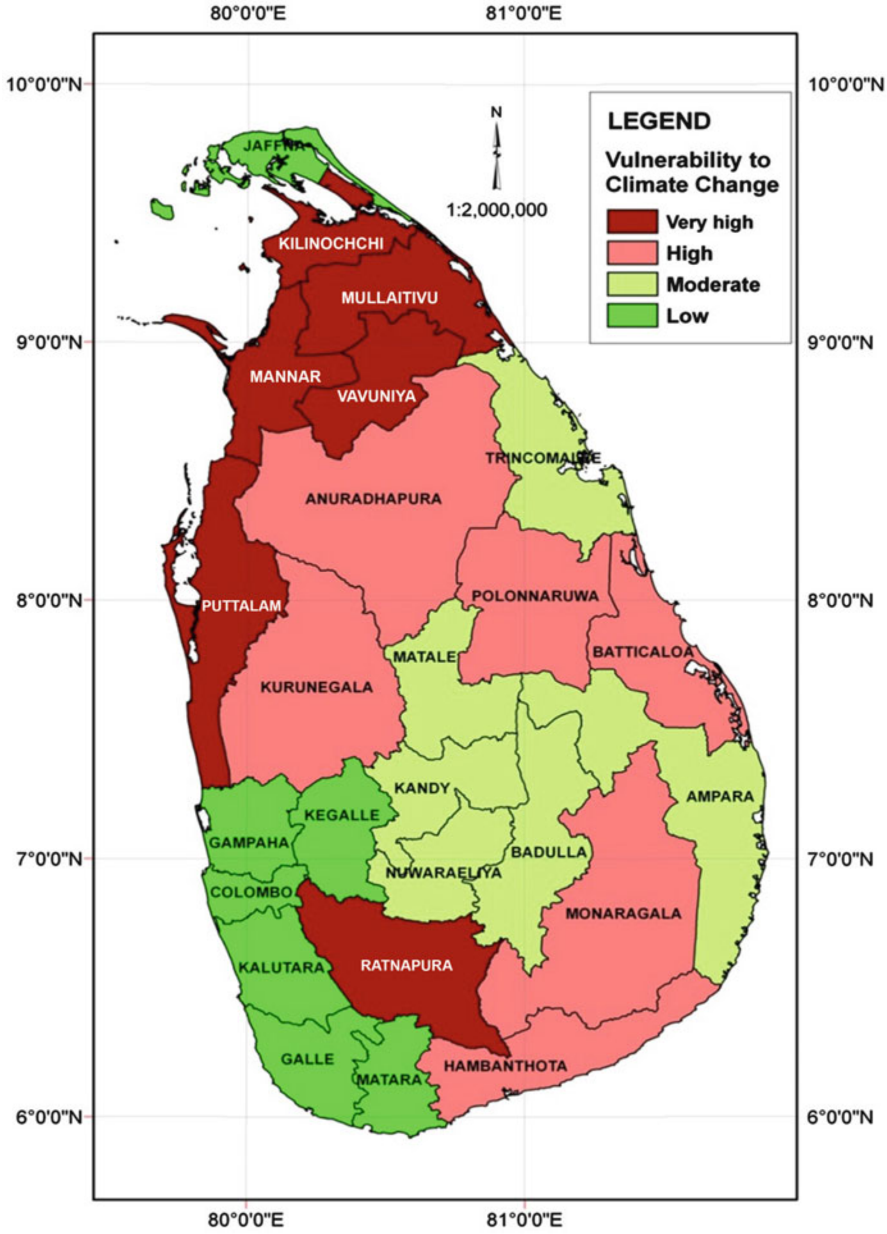


Fig. 7 Regional vulnerability of Sri Lanka to climate change (Source: Punyawardena et al. 2013a)

spatial variation. Sri Lanka's traditional farming systems have developed over hundreds of years with farmers managing production systems in the agroecological regions to best suit local environmental conditions. This has led to a rich agro-biodiversity in the island in terms food crops such as rice, cereals, pulses, vegetables, root and tuber crops, spices, and fruits. Changes in climatic conditions may, however, change the conditions that define the agroecological regions and reduce the productivity of crops and animals that are adapted to them. Conversely, they may allow new options in some areas. Currently, more than two million hectares are under some form of agriculture in Sri Lanka. However, much of the agricultural lands are located in the water-deficient Dry Zone where increased productivity of crops (other than paddy) depends almost entirely on rainfall.

In terms of food security, self-sufficiency in rice production has been the major strategy of agricultural policy since Sri Lanka gained independence in 1948. This has supported generation of employment and elimination of rural poverty. Sri Lanka reached the stated goal of self-sufficiency in rice in the year 2010 mainly due to the investments on research and development. The rice research outputs in Sri Lanka in the last half century further corroborate this contention in that on an average, for every 1 % increase in rice research investment, rice production increased by 0.37 % with an internal rate of return of 174 % in a tariff-protected regime and a benefit/cost ratio of over 2,300 (Niranjan 2004).

Poverty, climate change, decreasing arable agricultural land, and increasing population pressure are the main issues that render achieving the national-level food and nutrition security more challenging in Sri Lanka (Marambe 2012; Weerakoon 2013). The World Food Programme (2011) reported that out of the total population of Sri Lanka, 12 % are severely food insecure, of which 82 % are in the Northern and Eastern Provinces. Extreme climate events, such as the severe drought that prevailed over a period of 5–6 months in the year 2012, will provide its own challenges to food security in the near future. The Global Food Security Index 2013 (www.eiu.com/public/topical_report.aspx?campaignid=FoodSecurity2013) has ranked Sri Lanka 60th out of 107 countries. This index assists to identify and compare the core issues of food affordability, availability, access, and quality across countries.

Main Climate Risks for Food Security in Sri Lanka

The climate changes in recent decades in the forms of natural calamities like drought, flood, cyclone, accelerated land degradation, and sea-level rise pose serious threats to agricultural productivity and food security. Additional pressure coming from ever-increasing population, poor terms of trade, weak infrastructure, and limited access to modern technology and market restrict the options available for people to cope with the negative consequences of climate change. The main food-related agricultural products in Sri Lanka are crops such as rice and other field crops, fruits and vegetables, and animal products such as milk, meat, eggs, and fish. Sri Lanka has experienced frequent natural disasters in the wake of drought, flood, landslide, and cyclone events threatening its agricultural production. Coastal hazards such as coastal erosion and salinity intrusion to soils and aquifers are a common feature that affects agricultural production, especially in the drier parts along the Eastern coast of the country. Decreasing arable agricultural land, together with increasing population, renders these challenges more difficult to tackle. In Sri Lanka, most crops, e.g., coarse grains, legumes, vegetables, and potato, are likely to be adversely affected due to climate change (Titumil and Basak 2010).

The varied climatic conditions in the farming systems of Sri Lanka have given rise to a wide range of crop species and land races that are suited for different conditions of soils, rainfall, and altitude as well as to diseases and insect pests. Genetic diversity is particularly high among rice, other cereals, cucurbits, and vegetables such as tomato and eggplant, indicating the potential for crop improvement in the face of natural disasters such as climate change, as an adaptation measure. The genetic diversity of crop plants is the foundation for the sustainable development of new varieties for present and future challenges. Resource-poor farmers have been using genetic diversity intelligently over centuries to develop varieties adapted to their own environmental stress conditions. Systematic crop comparison programs under different agroecological regions of Sri Lanka through farmer participatory programs, strengthening the crop germplasm collection programs conducted by the Department of Agriculture with special focus on climate change, and creating access to and drawing in new genetic materials through intergovernmental programs to enhance food production would strengthen the strategic approaches for adaptation in Sri Lanka, thus minimizing the climate risk on food security.

In spite of the technological advances made on improved crop management, irrigation, plant protection, and fertilization, weather and climate are still key factors in agricultural value chain in Sri Lanka. Farming systems and agronomic practices in most agricultural regions of Sri Lanka have evolved in a close harmony with the prevailing climatic conditions of respective climatic regions of the island. However, it has been evident during recent decades that heritage of farming experiences and accumulated weather lore of centuries have become ineffective in agricultural planning process at all levels. The climate of the island has undergone a change to such an extent that correct amount of rainfall does not come at the correct time of the growing season.

Variability of both summer and winter monsoon rains and rains of convectional origin has increased significantly during recent decades in the world. As a result, both extremes, i.e., water scarcity and excess water, have become a recurrent problem in crop production and its entire value chain in Sri Lanka. More flexible farming approaches with water-efficient farming methods and crops to improve water productivity, construction of new reservoirs and trans-basin diversions to meet the demand, and management of water resource systems that respond to existing soil moisture and water storage levels are thus essential adaptation strategies to be used coupled with an improved climate forecast system.

Increasing ambient temperature is also inflicting several direct and indirect negative impacts on the crop growth. Urgent coping-up strategies such as identification of new areas for crop production, introduction of new climate-resilient crop varieties, organic agriculture, cropping systems including agroforestry, rainwater harvesting systems, and micro-irrigation techniques would assist in overcoming the negative impacts of higher environmental temperatures.

The intensively managed animal production sector is hardly vulnerable to the climate compared to impacts on the food crops sector. Nevertheless, the situation is obviously different for the extensively managed animal production sector where it is purely dependent on the rainfed pastoral systems and subjected to direct influence of climatic conditions. The animal production sector of Sri Lanka is signified mostly by smallholders spread across varying climatic regimes. The localized impacts of climate change are more visible in the areas where smallholder and subsistence farming are practiced as they are highly vulnerable to the localized trends of climate change. However, the high genetic variability that exists, especially among indigenous animal categories, and their adaptability to the diverse and localized climatic regimes in the country render a positive influence in building up resilience in smallholder sector by balancing the impacts of climate variability within the system of farming. Despite the importance of smallholder systems to the animal production sector of Sri Lanka, an understanding on the interaction of climate change and animals in the country is not effective enough to face the future development challenges of the sector.

Irrespective of the sectoral characteristics, the impact of climate change on any sector depends on how and what intensity the rainfall regime in a given area is variable along with the increasing environmental temperature of the same area. In addition, if the area lies in a coastal environment, the sea-level rise and the risk of increased storm surge would bring in more additive negative effects.

Impacts of Changes in Rainfall and Soil Regimes on Food Security

Increased occurrence of extreme rainfall events due to climate change, droughts, and floods has become a common feature of the climate of Sri Lanka during recent decades. It is clear until the mid-1980s that any within- or between-season variation in rainfall could be statistically accommodated within a 95 % confidence interval. However, weather aberrations that have taken place after the late 1980s could be considered as unprecedented because they fall outside even the 90 % confidence limits. Under such situations, crop losses due to decreased soil moisture and excess water, both in terms of quantitative and qualitative, are inevitable.

In Sri Lanka, more than the temperature regime, the amount and distribution of seasonal rainfall have a profound impact on the productivity and food security in different agroecological environments. Out of the 46 agroecological regions of the country, 31 of them spreading across both Dry and Intermediate Zones are more delicately poised than those of the Wet Zone in relation to rainfall seasonality and variability. Aberrations or change in rainfall pattern will therefore have a major impact on food security in the Dry and Intermediate Zones. These two climatic zones have four major great soil groups of agricultural significance, namely, reddish brown earths (RBE), non-calcic brown soils (NCB), red-yellow latosols (RYL), and regosols, that will be affected at varying degrees under variable and changing climate, thus affecting food security of the country, as described below.

Reddish-Brown Earth Region

Reddish-brown earth (RBE) is the most widespread great soil group of Sri Lanka, and it occupies mainly in DL_{1a}, DL_{1b}, DL_{1c}, DL_{1d}, DL_{1e}, DL_{1f}, DL_5, and IL_2 agroecological regions covering an aerial extent of 1.61 million hectares. The soil moisture relationships of this soil are characterized by a low water holding capacity with a rapid release of soil moisture at tensions lower than one atmosphere. It is also characterized by having a gravel layer in the sub-horizon. The depth to this gravel layer is quite variable, depending on the agroecological region. Due to the aforesaid soil moisture characteristics of this soil group, negative anomalies of seasonal rainfall that may arise frequently under a changing climate will manifest as drought injuries in upland crops at varying degrees. It is equally true that the positive anomalies of seasonal rains could lead to excess soil moisture conditions with drainage problems in upland crops due to impervious gravel layer in the subsoil of this soil group.

About 80 % of the country's coarse grains (i.e., maize and millet) and grain legumes (green gram, cowpea, black gram, and soybean) are grown on this soil group during the *Maha* season in the above-stated agroecological regions. Thus, it is likely that climate change would exacerbate the crop losses and severe instability in a year-to-year production in those farming systems due to drought and excess soil moisture conditions.

The other most dominant farming system associated with this soil group is rice cultivation in irrigable lowland during the *Maha* season and perhaps during the *Yala* season depending upon the availability of water in the tank system (irrigation reservoirs). These tanks have been constructed as a cascade system by blocking the natural drainage ways in a watershed by means of earthen dams to collect the rain and runoff at appropriate places to form a series of small tanks along the drainage way. More importantly, these tanks, known as the "minor tanks" (reservoirs with an irrigable area of less than 80 ha), provide the livelihood of a large section of the rural population in the RBE region. An estimated number of 8,500 working minor tanks are reported to provide water for 43 % of the total irrigated area in the country. These estimates suggest the great importance of minor tanks in Sri Lanka, especially for the RBE region. Generally, the catchment of these tanks is relatively small, owing to the undulating landscape of the region.

Shifting cultivation or chena cultivation is the common land use practice in these catchments for decades by the villagers, and as a result catchment yield has been declining gradually over the years. Apart from reduced inflow to the reservoirs, chena cultivation has also led to soil erosion and subsequent sedimentation of tanks, leading to reduced storage and increased surface/depth ratio.

Rainfall regime in this region has become highly erratic during the recent times due to climate change, resulting in below-average storage conditions even during

Maha seasons. Meanwhile, increasing ambient temperature regime, coupled with high surface/depth ratio of tanks in this region, has resulted in rapid drying out of these tanks to make the situation become worse. All these have led the farmers who find their livelihood from these tanks to look for other livelihood alternatives or migrate to urban areas for nonagricultural livelihood options.

Non-calcic Brown Region

The non-calcic brown (NCB) soil group is mainly confined to DL_{2a} and DL_{2b} agroecological regions in Ampara and Batticaloa districts along with the IL_3 region in the northern part of Kurunegala district, covering a total area of about 165,000 ha. This is a coarse-textured soil with very poor chemical properties. Due to the unimodal nature of rainfall pattern in the DL_{2a} and DL_{2b} agroecological regions, only a single crop is possible in those regions during the *Maha* seasons.

During the recent times, the variability of NEM has been increased dramatically due to climate change, and as a result a significant instability in season-to-season rainfed agriculture production is inevitable in this region. Nevertheless, wetland rice cultivation in valley bottoms, where NCB occurs in a complex association with relatively fertile old alluvium soils, may manage to give good yields even under a changing climate unless extreme positive rainfall anomalies cause flood damages in these regions. The IL_3 agroecological region in Kurunegala district is frequently subjected to moisture stress due to its own rainfall pattern and coarse texture of the underlying soil. Thus, negative anomalies of rainfall may aggravate the drought injuries in this region even with the dominant tree crop of coconut.

Red-Yellow Latosol Region

The great soil group red-yellow latosol (RYL) mainly occurs in the DL_3 agroecological region in the Northern Province with an aerial extent of 320,000 ha. It generally overlies a very porous limestone substrate, which provides a stable groundwater source throughout the year. Cultivation of high-value crops such as chili, onion, and vegetables under lift irrigation is the common cropping system in this region. Even though it was used to be a sustainable land use system with traditional lifting devices (*Thula Kinnaru*), the use of motor-powered lifting pumps has exponentially increased the rate of groundwater extraction, which could increase the vulnerability of the farming system to climate change.

Regosol Region

The regosol soils are located mainly on the elevated beach plains with a flat topography in the Batticaloa and Puttalam districts. Despite the dry environment that prevails in these regions, the soil supports very productive coconut plantations and cashew cultivations by underlying freshwater supplies found at a shallow depth. In some places (Kalpitiya peninsula), these soils have been widely used for intensive cultivation of high-value crops such as chili, onion, and vegetables under lift irrigation from shallow wells. However, extraction of water extensively from the shallow water supply would make the entire farming system in these regions highly vulnerable to climate change, even posing threats to drinking water supplies of the community.

Generally, rice cultivation in the Dry and Intermediate Zones possesses a considerable resilience to climate change compared to other cropping systems in those regions due to the availability of irrigation water. The animal component of the widespread mixed (crop-animal) systems across all the above regions will have an indirect influence of the rainfall pattern and soil regime due to the changes in feed availability. A recent study has shown that even the Wet Zone of Sri Lanka is undergoing significant changes in its rainfall rhythm (Premalal and Punyawardena 2013). Some years have become "years of extremes" where within a shorter time period (i.e., 1 month), a flood-stricken area of the Wet Zone could turn into a drought-affected area.

Impact of Floods and Drought on Food Security

In the food crop sector, the occurrence of floods has affected paddy production in Sri Lanka significantly compared to other crops, with heavy damages being recorded during *Maha* season 2008/2009, resulting from a peak of flood incidences in December and March. Kilinochchi and Ampara districts in the Dry Zone of Sri Lanka have reported the highest losses of paddy due to flooding during the 6-year period from 2005 to 2010 (Fig. 8).

Poultry industry was highly affected by flood incidences during the period 2005–2008 when compared to the rest of the animal production sector. Losses in the animal production sector were high during the *Maha* season, as in the case of crops, and the month of December has recorded the peak of animal losses due to floods. Kilinochchi, Jaffna, and Ampara districts have shown higher levels of animal losses due to the occurrence of floods during the period 2005–2010 (Fig. 9).

The continuous occurrence of drought over the years has resulted in a consistent pattern of crop damage, with a severe impact recorded in 2009. Crop losses were higher at the onset of the *Yala* season and at the end of the *Maha* season. The highest crop losses were observed in Kurunegala (Intermediate Zone) and Matale (Wet Zone) districts during the period 2005–2010 (Fig. 10).

Drought has also affected the poultry and cattle industries over the period 2005–2010. The cattle industry was significantly affected by drought especially during 2006 and 2007, while the poultry industry was badly hit in 2009. The highest animal loss was observed in Kilinochchi and Batticaloa districts in the Dry Zone during the period 2005–2010 (Fig. 11).

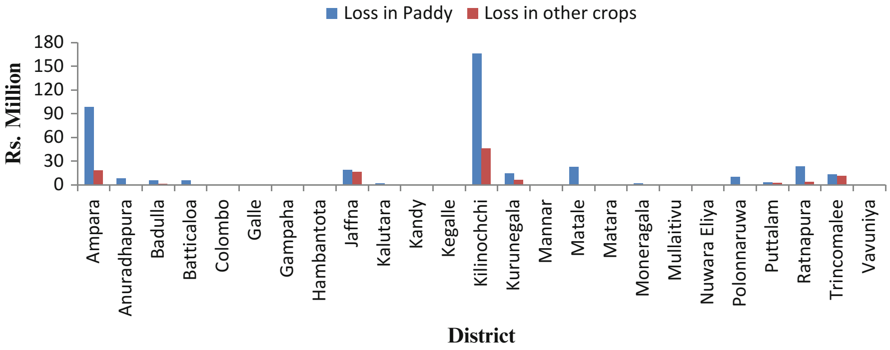


Fig. 8 Spatial distributions of crop losses due to the occurrence of floods in Sri Lanka during the period 2005–2010 (Source: www.desinventar.lk)

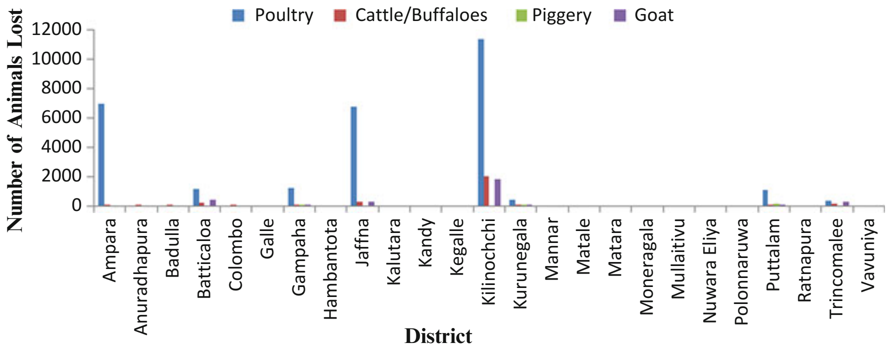


Fig. 9 Spatial distributions of animal losses due to the occurrence of floods in Sri Lanka during the period 2005–2010 (Source: www.desinventar.lk)

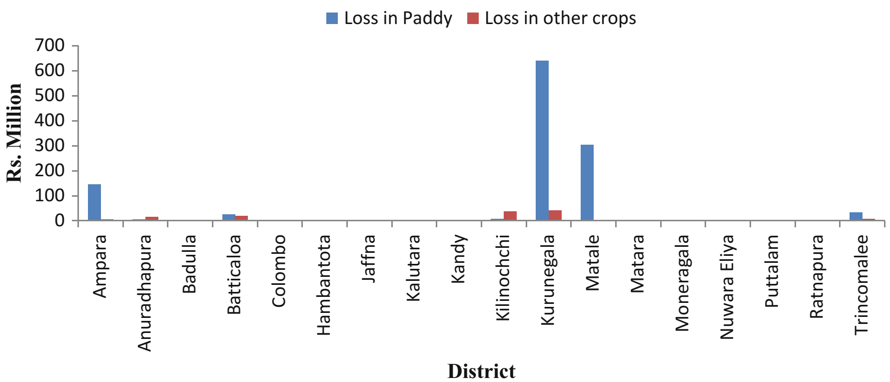


Fig. 10 Spatial distributions of crop losses due to the occurrence of drought in Sri Lanka during the period 2005–2010 (Source: www.desinventar.lk)

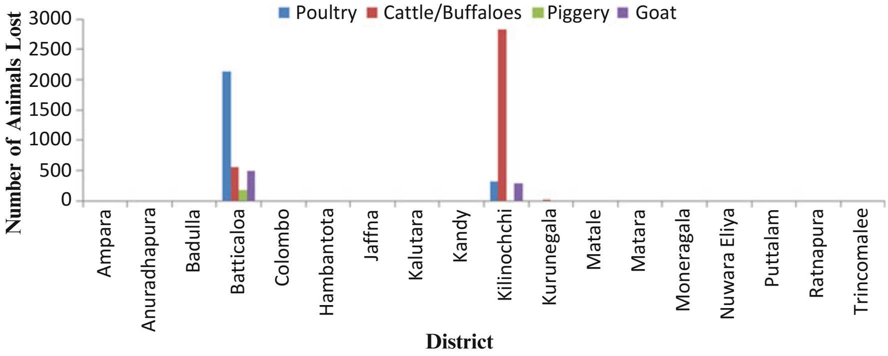


Fig. 11 Spatial distributions of animal losses due to the occurrence of drought in Sri Lanka during the period 2005–2010 (Source: www.desinventar.lk)

Impacts of Increased Temperature Regime on Food Security

Being a tropical island with a uniformly high-temperature regime, most of the cultivated crops in Sri Lanka operate near the maximum of the optimum temperature range of respective crops. This phenomenon is true for animal production, too. Thus, crop injuries and animal production losses due to high temperatures are inevitable in Sri Lankan agriculture with increasing temperatures. This is of particular importance for the country's major staple food, rice. It is a well-established fact that high-temperature injuries in rice are inevitable if the plant is exposed to an ambient temperature that exceeds 33 °C just for 60–90 min at the anthesis stage (flowering; Punyawardena 2011). It was used to be a rare event to experience such high values of daytime temperature in major rice-growing regions of the country; however, recent agro-meteorological observations have confirmed that the frequency of such temperature events has increased significantly in both Dry and Intermediate Zones, especially during *Yala* seasons, resulting in high rates of unfilled grains due to increased spikelet sterility (known as *Ehela Pussa*). Higher temperature regimes will also increase the evapotranspiration losses, leading to frequent soil moisture stress conditions in upland crops. Recent investigations have clearly shown that the nighttime minimum temperature in many locations of the country has been increasing during recent decades, resulting in diurnal temperature range to become increasingly narrower.

Even though root and tuber crops are more resilient to temporal variations of rainfall, a decreasing trend of diurnal temperature range is likely to cause negative impacts on the root and tuber crop production in the country. This will be highly reflected in potato production in the central hills as the existing environmental temperature regime is suboptimal for the crop even in the up-country region where the crop is mainly concentrated. The quality of the harvestable parts of crops is also to be affected negatively due to several reasons, which may arise due to climate change.

Increased temperature, especially the nighttime minimum temperature, tends to decrease the sugar translocations to harvestable fruits and thus reduce the quality by increasing sour taste in fruit crops. Meanwhile, the fiber content of the harvestable parts of crops is also likely to increase under increased temperature regimes, thereby reducing the palatability of them.

The heat stress conditions in animals under increased ambient temperature reduce the fertility and productivity of all categories of livestock and poultry, especially in high-yielding exotic breeds. This has a direct influence on production losses in the case of dairy and egg production. As the heat load accumulation inside the animal body has a profound adverse effect on the rate of growth, the meat production also gets affected significantly irrespective to the system of operation, intensive or extensive.

The yield of almost all crops grown and animals reared in the country would also be negatively affected due to increased insect pest damages and infestation by all kind of pathogens such as bacteria, virus, and fungi especially under humid conditions. Even though higher yield losses due to increased weed infestation are likely to occur with increasing temperature, recent studies have shown that there is no such trend under local conditions. However, it is too early to generalize that such threats would not occur in the future.

Apart from the direct impact of increased variability of rainfall and rise of ambient temperature, indirect effects of increased rainfall intensities are of special significance in terms of land degradation, which has a significant bearing on the crop production in Sri Lanka. Increased temperature is likely to enhance the local-scale convection and thereby to form more cumulonimbus clouds, giving rise to high-intensity rains (>25 mm/h). Such rains invariably will wash away the fertile top soil of arable lands and will lead to subsequent siltation and eutrophication of downstream reservoirs and any other surface water bodies. Moreover, increased temperature and frequent and negative rainfall anomalies are also likely to cause high evaporative demand of the atmosphere. This can cause salinization of agricultural lands in the semiarid parts of the country.

Impacts of Sea-Level Rise on Food Security

Being an island, Sri Lanka is highly vulnerable to sea-level rise with varying degrees of sectoral impacts. It is highly confident that seawater intrusion to agricultural lands will be an inevitable event under a changing climate, which will lead to further reduction of land available for agriculture.

Increased sea-level rise will also exacerbate the coastal erosion, giving rise to some additional pressure on land available for agriculture, directly and indirectly. Also, it may reduce the quality of both drinking and irrigation water in coastal regions by disturbing the interface between freshwater and brackish water. It is highly likely that sea-level rise will disturb the Ghyben-Herzberg lens of freshwater found underneath of regosol in coastal regions. These freshwater lenses provide the irrigation water for intensive agriculture in those areas.

Adapting to Climate Change Aiming at Food Security

Being cognizant of the importance of adapting to climate change, the government of Sri Lanka has taken several initiatives at the policy level by developing the National Climate Change Policy (NCCP) of 2012 (Ministry of Environment 2012) and the National Climate Change Adaptation Strategy (NCCAS) 2010–2016 (Ministry of Environment and Natural Resources 2010). While the three main policies that deal with the agriculture sector related to food security, namely, the National Agriculture Policy of 2007 (Ministry of Agriculture and Agrarian Development 2007), National Livestock Development Policy of 2007 (Ministry of Livestock and Rural Community Development 2007), and the National Fisheries and Aquatic Resources Policy of 2006 (Ministry of Fisheries and Aquatic Resources 2006), are in operation, the NCCP and NCCAS are expected to mainstream climate change adaptation into the national planning and development process.

Rice

Rice being the major staple of Sri Lankans, more efforts have been made by the scientific community to provide suitable materials resilient to changing and variable climatic scenarios. A recent study has indicated that rice farmers in the Kurunegala district of Sri Lanka (Intermediate Zone) have lost 44 % of the agriculture income every season due to drought (Chandrasiri 2013). Chandrasiri (2013) also reported that the awareness of climate change among the farmers is high, but the adaptation is poor due to the lack of knowledge on adaptation methods, unavailability of prior information on climate change, absence of suitable cultivars, and lack of funding. A recent study (Herath and Kawasaki 2012) also reported that the variability of rice yield under the future climate conditions in the Kurunegala district of Sri Lanka shows small increasing trends, averagely 1.7 % and 2.4 % under the A2 and B2 scenarios, respectively. More yield-improving techniques are required to achieve the future rice requirement of the country under the impacts of climate change.

Several successful attempts have been made in the rice production sector in the technological front to meet the challenges of climate change. The development of rice varieties, which are of short duration and suitable for short growing seasons (Harris and Shatheeswaran 2005) and high CO_2 concentration (De Costa et al. 2007), is in the forefront of technological innovations. The recent release of ultrashort-duration rice varieties by the Sri Lanka Department of Agriculture such as Bg250 maturing in 75–80 days is a positive response by the government of Sri Lanka to cope up with climatic changes. Gunawardana et al. (2013) reported on the potential for adoption of aerobic growing conditions for rice varieties minimizing the water use under changing climatic conditions while assessing the competition for weeds.

Studies carried out in Sri Lanka to identify the role of traditional paddy varieties and organic practices in adapting to climate change especially in the coastal belt have indicated that farmers have perceived climate change in rainfall patterns, intensity and timings, changes in the cloud formations, and other indicators such as the behavior of animals. As the sustainability of food production through traditional farming patterns is being challenged, farmers have been following water-conserving agronomic practices such as *Kekulama* or *Manawari* system and *Nava Kekulama* (dry-sowing systems; Upawansa 2013) and the System of Rice Intensification (SRI) (Somaratne 2010) and are also making informed choices in species selection by combining local knowledge on species and varieties under the guidance of several NGOs (Berger et al. 2009). Jayawardena et al. (2010) reported that paddy cultivation in the Dry and Intermediate Zones in Sri Lanka under zero-tillage condition has enabled a reduction in cost of production and enhanced water conservation without significantly affecting the yield. Breeding of salt-tolerant rice varieties is also a primary adaptation measure to maintain national rice production levels and ensure food security in the face of expanding salinity due to sea-level rise. In this regard, the salt-tolerant rice variety At354 (3½ month age class) has been developed by the Sri Lanka Department of Agriculture to meet food production challenges under saline conditions. Salinity in paddy fields could also be overcome by a combination of agronomic measures including improved field drainage, application of organic manure, rice straw and burnt paddy husk, and transplanting rice instead of direct seeding.

With more frequent extreme rainfall events, the area under major irrigation reservoir schemes (reservoirs with an irrigable area of more than 200 ha) in the Wet and Intermediate Zones that practice rice + rice annual cropping pattern would not be able to claim the usual share from the trans-basin diversion structures. This has forced the farming community to reduce the extent under cultivation or explore other adaptation options such as “shared cultivation” (*Bethma* system) but at the expense of the productivity of the system. Moreover, increased occurrence of extreme positive rainfall anomalies is likely to cause severe damages to existing irrigation infrastructure of major irrigation schemes, thus limiting the water availability for crop production systems under these reservoirs.

Traditional agriculture practices coupled with endogenous paddy varieties have proven to be more successful in facing climate change events such as droughts and floods (Sharma and Rai 2010). There are many traditional paddy varieties in existence today in Sri Lanka, which have strong characteristics that help them survive climate change impacts such as droughts, heavy rains, and floods compared to newer varieties used in chemical-intensive paddy cultivation (Rathnabharathi 2009). This vigor is based on certain characteristics unique to traditional paddy varieties. The traditional varieties are capable of surviving in the nursery until the field conditions are favorable for planting. Traditional varieties are tall with a strong stem compared to the new improved varieties, thus helping them to withstand heavy rains, winds, and droughts. The husk of the paddy seed of traditional varieties can withstand waterlogged as well as drought conditions (Rathnabharathi 2009). Traditional rice varieties such as *Hata da vee* that survives long dry spells are being cultivated in selected areas in the Dry and Intermediate Zones of the country. Farmers are being assisted by several NGOs to identify traditional paddy varieties such as *Pokkali*, *Kaluheenati*, and *Madathawalu*, which can be grown in sandy and saline soils with appropriate management practices. To cope with shifting seasons due to unpredictable fluctuations in rain and temperature, long- and short-age traditional varieties such as *Hata da vee* (maturing in 70 days) and the *Maha ma vee* (maturing in 6 months) are cultivated by farming communities in different localities of Sri Lanka. Paddy farmers under the minor tank systems in the Dry Zone of Sri Lanka are aligning farming activities with the recognized seasonal pattern of rainfall and managing rainwater harvested in the commonly owned village tanks (Senaratne and Wickramasinghe 2010). Amarasingha et al. (2014) reported that changing planting date of rice according to the onset of rainfall can reduce the irrigation water requirement and risk of rice cultivation. Early onset of rainfall coupled with early planting has resulted in higher yield and water productivity across different irrigation management options, while a higher variability has been observed in both water productivity and yield at a late onset and planting with subsistence irrigation. Dharmarathna et al. (2014) also reported that advancing the rice planting date by 1 month would be a non-cost climate change adaptation strategy for rice production in the Kurunegala district of Sri Lanka.

Coconut

Analysis of coconut production data from 1971 to 2001 has shown that the foregone income to the economy due to crop shortages from unfavorable climate has varied around US$ 32–73 million (Fernando et al. 2007), and the additional income to the economy from favorable climate years producing a crop glut was US$ 42–87 million. This implies the potential for significant economic benefits from investments in adaptation that would reduce the variability in coconut production, caused by variation in climate. Some varieties such as Tall x Tall and Tall x San Ramon have been recommended for drought-prone areas in Sri Lanka to meet the challenges of climate change. Furthermore, the variety Dwarf Brown appears promising for plant breeders as an ideal parent material due to some characteristics such as nonseasonality, high-yielding capacity (higher number of nuts per bunch and higher number of inflorescences per palm per year), and relatively higher tolerance to water stress conditions compared to those of other dwarf varieties (Ministry of Environment 2010).

Other Food Crops

Several strategies have been adopted in the other food crops sector (excluding rice), covering many food crops at the national and household level to cope up with the changes in climate, such as (a) soil moisture conservation with mulching, soil erosion control under intensive rainy conditions to minimize surface runoff and improve the water-retention capacity of soil; (b) growing low water-demanding crops such as mung bean (green gram), finger millet, and sesame and short-age crops for mid-season cultivation with appropriate agronomic management practices; and (c) adjusting the cropping calendar according to changes in the rainfall pattern (Howden et al. 2007).

Animal Production

Livestock and poultry form an important subsector in the social and economic context of the country, and hence strategies for adaptation and risk aversion to face the challenges brought by the changing and variable climatic conditions are crucial. Strategies for climate change adaptation have not been specifically highlighted in the National Livestock Development Plan – 2010 (Ministry of Livestock and Rural Community Development 2010), which is implemented at present. The animal production sector implements a strategic approach in animal breeding activities since 1994 according to the climatic regions by using different animal breeds and their crossbreds.

A greater emphasis has been given for the dairy subsector in the implementation of breeding strategies as the country's main strategy in terms of food security in relation to animal production is to bring self-sufficiency in milk and milk products. The interim target has been set to achieve 50 % self-sufficiency by the year 2015. However, there are no pasture development strategies or recommendation in place according to the climatic conditions due to various limitations that exist in the field level. Given the fact that Sri Lanka possesses a diverse climate as well as production environments, the benefit of development of climate-resilient systems for feed improvement is still pending.

The subsectors other than dairy have breeding strategies specified for each sector, considering the adaptability of different genotypes. In addition, sustainable utilization of indigenous animals has been specifically identified in the animal breeding guidelines (Ministry of Livestock and Rural Community Development 2010). Many efforts have been taken in the past in developing locally adopted breeds suitable for different climatic regimes in the country. Kottukachchiya goat breed (Silva et al. 2010) developed as a dual-purpose breed suitable for the Dry Zone in Sri Lanka and CPRS poultry breed (Gamage et al. 2013) developed for local climatic conditions and feeding regimes are few examples of such attempts.

Homegardens

"Homegarden" (HG) is a complex but sustainable land use system that combines multiple farming components in the homestead and provides environmental services, household needs, employment, and income-generation opportunities to the households (Weerahewa et al. 2012). A study conducted to assess the vulnerability of HGs to climate change and its impact on household food security in Sri Lanka (Marambe et al. 2013) has identified four categories of climate change adaptation strategies adopted by homegardeners, namely, (1) changing planting date, (2) changing agronomic practices, (3) changing technology such as the use of new varieties and irrigation equipment, and (4) the use of soil and water conservation measures. Family size and perceptions on climate change have positively affected the likelihood of adoption of new technologies in Sri Lanka. Male-headed households also tend to adapt more than that of the female-headed households. The factors that negatively affect adaptation in Sri Lankan HGs included ownership of animals, HG size, age of the head of the household, and plant diversity of the HG (Marambe et al. 2012). Commercial orientation, perceptions on climate changes, years of experience of the homegardeners, and location of farming have significantly influenced the probability of adoption of adaptation strategies (Daulagala et al. 2012).

Conclusions and Way Forward

The sustainable development challenge remains urgent and acute, where poverty and food insecurity impact the lives of a sizable population in developing countries including Sri Lanka. Climate change renders achieving the national-level food security more challenging, thus making sustainable development a daunting task. The United Nation's Rio+20 summit in 2012 has thus committed governments to create six Sustainable Development Goals (SDGs) to be integrated to the follow-up of Millennium Development Goals (MDGs) after the 2015 deadline. A new approach for long-term sustenance in food security is a necessity by effectively drawing in ecological principles to improve the productivity and efficiency of agriculture and food systems while reducing negative environmental impacts. Substantial gains in productivity in agriculture and food systems can be realized through investment, innovation, policy, and other improvements.

Agriculture and food systems face many challenges, making it more difficult to achieve the primary objective of meeting the world food demand. An intimidating set of unprecedented challenges and risks including the increasing competition for land, water, and other natural resources by nonagricultural sectors affect the food security of the current and future inhabitants of the world. Food security is multidimensional, and the population growth and changes in consumption patterns associated with rising incomes drive greater demand for food and other agricultural products. Advancements in the productivity frontier, transformations in production systems, and enhanced food and environmental safety are three goals to achieve by countries, and Sri Lanka is not an exception.

Climate change has continued to affect agricultural productivity (crops and animals) through shifts in rainfall patterns, changing temperature regimes, and increased climate variability as well as climatic extremes. Farmers in Sri Lanka have observed these changes, but their historic weather knowledge and experience are progressively becoming less useful in the agricultural planning process due to the rapid changes in the climate. The existing short-term (3–10 day) weather forecasts have provided limited assistance for planning in the agricultural sector, and hence, access to reliable intra-seasonal to seasonal climate forecasts (1 month to multi-month time frames) could provide farmers with a complementary set of response options, which can further help reduce production risks and ensure food security. Such mid-range forecasts could assist farmers and the policy makers to develop improved climate risk management strategies such as which crop to be planted and when, fertilizer application rates, and timing of irrigation activity and harvest. While seasonal climate forecasts in the tropical systems have been a challenge for modelers globally, valuing existing or even marginally improved forecasts could effectively be included in decision making in agriculture.

Effective intra-seasonal to seasonal management responses to short-term climate variability are key means to progressively adapt to climate change (McKeon et al. 1993).

Climate-resilient food production approaches would be the path to sustain food security for sustainable development in Sri Lanka. A research agenda closely tied to sharing of information across research, i.e., discovery, development, and deployment, is an imperative. Advancements in productivity frontier, transformations in production systems, and enhanced food and environmental safety are three priority research themes in this regard in the attempt to adapt to climate change scenarios while ensuring food security. The purpose-driven research in sustaining food security should address: (1) seasonal climate forecasting with appropriate statistical models and numerical weather predictions, crop/animal growth modeling with appropriately parameterized models, and assessment of adaptation and resilience levels of different crops and animals; (2) judicious use of wild relatives and natives for breeding/propagation for quality products and biotic and abiotic stresses, reengineering crop photosynthesis, and reverse phenology; (3) introduction and promotion of the use of precision agriculture, smart fertilizers, agroforestry, climate-smart agriculture, watershed management to minimize soil erosion and environmental contamination, and water-saving irrigation techniques; and (4) reduction in waste related to agriculture and food aiming at food safety, improved food and nutrient use efficiency, recycling and reuse, value addition, and value chain management. Realizing these goals will require an exceptional level of collaboration among stakeholders in the agriculture value chain including the government, private sector, civil society groups, academia/scientists, farmers, and consumers. Science and technological progression will make it possible for sustainable agriculture to become the new global standard, but the main factors resisting this change are political will, lack of policy coherence at many levels, financing, governance, and human behavior.

Acknowledgments The authors wish to acknowledge the financial assistance provided by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia to carry out this review through a grant agreement deed on “Improve climate forecasting to improve food security in Indian ocean rim countries” (AusAID agreement 59553) given to the Agriculture Education Unit (AEU) of the Faculty of Agriculture, University of Peradeniya, Sri Lanka.

References

Amarasingha RPRK, Galagedara LW, Marambe B, Silva GLLP, Punyawardena R, Nidumolu U, Howden M, Suriyagoda LDB (2014) Improving water productivity by planting rice with the onset of *Maha* season rain in the dry zone of Sri Lanka: a modeling approach. Trop Agric Res 25(3):277–286

Berger R, Weregoda R, Rathnabharathie V (2009) Participatory rice variety selection in Sri Lanka. Particip Learn Action 60(1):88–98

Chandrasiri WACK (2013) Farmer’s perception and adaptation to climate change: a case study in vulnerable areas of Kurunegala district. Ann Sri Lanka Dept Agric 15:13–23

Daulagala C, Weerahewa J, Marambe B, Pushpakumara G, Silva P, Punyawardena R, Premalal S, Miah G, Roy J, Jana S (2012) Socio-economic characteristics of farmers influencing adaptation to climate change: empirical results from selected homegardens in South Asia with emphasis on commercial orientation. Sri Lanka J Adv Soc Stud 2(2):71–90

De Costa WAJM, Weerakoon WMW, Chinthaka KGR, Herath HMLK, Abeywardena RMI (2007) Genotypic variation in the response of rice (*Oryza sativa* L.) to increased atmospheric carbon dioxide and its physiological basis. J Agron Crop Sci 193(2):117–130

Dharmarathna WRSS, Herath S, Weerakoon SB (2014) Changing the planting date as a climate change adaptation strategy for rice production in Kurunegala district, Sri Lanka. Sustain Sci 9:103–111

FAO (2009) Declaration of the World Summit on Food Security, WSFS 2009/2. Available at http://www.fao.org/wsfs/wsfs-list-documents/en/

Fernando TK, Chandrapala L (1995) Climate variability in Sri Lanka – a study of trends of air temperature, rainfall and thunder activity. In: Proceedings of the international symposium on climate and life in Asia-Pacific, Brunei

Fernando N, Zubair L, Peiris TSG, Ranasinghe CS, Ratnasiri J (2007) Economic value of climate variability impacts on coconut production in Sri Lanka. AIACC working paper no 45, START, Washington, DC

Gamage de S, Silva P, Abeykoon NDF, Ibrahim MNM, Mwai O (2013) Introduction of an improved indigenous chicken to the scavenging poultry sector. In: Proceedings of the world conference of animal production, Beijing, p 113

Gunawardana WRN, Ariyarathne M, Bandaranayake P, Marambe B (2013) Control of *Echinochloa colona* in aerobic rice: effect of different rate of seed paddy and post-plant herbicides in the dry zone of Sri Lanka. In: Bakar B, Kurniadie D, Tjitrosoedirdjo S (eds) Proceedings of the 24th Asian Pacific Weed Science Society (APWSS) conference, Bandung, pp 432–437

Harris KD, Shatheeswaran T (2005) Performance of improved four test rice entries of short duration (2.5 months) in the eastern region of Sri Lanka. In: Proceedings of the 61st annual session of Sri Lanka Association for the Advancement of Science (SLASS), section B. Colombo, p 21

Herath S, Kawasaki J (eds) (2012) Comparative studies on development strategies considering impacts of adaptation to climate change. CECAR series no 12, UNU-ISP. Tokyo

Howden SM, Soussana JF, Tubiello FN, Chhetri N, Dunlop M, Meinke HM (2007) Adapting agriculture to climate change. Proc Natl Acad Sci 104:19691–19696

http://www.desinventar.lk

https://www.eiu.com/public/topical_report.aspx?campaignid=FoodSecurity2013

Jayawardena SN, Abeysekera SW, Gunathilaka N, Herath HMJK (2010) Potential for zero tillage technique in rice and other field crop cultivation in rice based cropping systems in the dry and intermediate zones of Sri Lanka. In: Weligamage P, Godaliyadda GGA, Jinapala K (eds) Proceedings of the national conference on water, food security and climate change in Sri Lanka. International Water Management Institute (IWMI), Colombo. 9–11 June 2009. pp 65–74

Marambe B (2012) Current status and issues of food and nutrition security in Sri Lanka. In: National food and nutrition security conference Sri Lanka – towards a nutritious and healthy nation, Colombo, 17 Oct, p 43

Marambe B, Weerahewa J, Pushpakumara G, Silva P, Punyawardena R, Premalal S, Miah G, Roy J, Jana S (2012) Adaptation to climate change in agro-ecosystems: a case study from homegardens in South Asia. In: Proceedings of the MARCO symposium 2012 – strengthening collaboration to meet agro-environmental challenges in Monsoon Asia, National Institute for Agro-Environmental Science, Tsukuba, pp 81–87

Marambe B, Pushpakumara G, Silva P, Weerahewa J, Punyawardena BVR (2013) Climate change and household food security in homegardens of Sri Lanka. In: HPM Gunasena, HAJ Gunathilake, JMDT Everard, CS Ranasinghe, and AD Nainanayake (eds) Proceedings of the international conference on climate change impacts and adaptation for food and environmental security, Colombo, pp 87–99

McKeon GM, Howden SM, Abel NOJ, King JM (1993) Climate change: adapting tropical and subtropical grasslands. In: Baker MJ (ed) Grasslands for our world. SIR Publishing, Wellington
Ministry of Agriculture and Agrarian Development (2007) National agriculture policy. Ministry of Agriculture and Agrarian Development, Battaramulla
Ministry of Environment (2010) Sri Lanka second national communication to the UNFCCC. Ministry of Environment, Battaramulla
Ministry of Environment (2012) National climate change policy. Ministry of Environment, Battaramulla
Ministry of Environment and Natural Resources (2010) National climate change adaptation strategy for Sri Lanka 2011–2016. Ministry of Environment and Natural Resources, Battaramulla. Available at http://www.climatechange.lk/adaptation/Files/Strategy_Booklet-Final_for_Print_Low_res(1).pdf
Ministry of Fisheries and Aquatic Resources (2006) National fisheries and aquatic resources policy. Ministry of Fisheries and Aquatic Resources, Colombo
Ministry of Livestock and Rural Community Development (2007) National livestock development policy. Ministry of Livestock and Rural Community Development, Colombo
Ministry of Livestock and Rural Community Development (2010) The national animal breeding policy – guidelines and strategies for livestock in Sri Lanka. Department of Animal Production and Health/Ministry of Livestock and Rural Community Development, Colombo
Niranjan F (2004) PhD thesis, Postgraduate Institute of Agriculture, Peradeniya
Nissanka SP, Punyawardena BVR, Premalal KHMS, Thattil RO (2011) Recent trends in annual and growing seasons' rainfall of Sri Lanka. In: Proceedings of the international conference on the impact of climate change in agriculture. Faculty of Agriculture, University of Ruhuna, pp 249–263
Premalal KHMS, Punyawardena BVR (2013) Occurrence of extreme climatic events in Sri Lanka. In: Gunasena HPM, Gunathilake HAJ, Everard JMDT, Ranasinghe CS, Nainanayake AD (eds) Proceedings of the international conference on climate change impacts and adaptations for food and environment security. Hotel Renuka, Colombo, pp 49–57
Punyawardena BVR (2007) Agro-ecology (map and accompanying text), National Atlas of Sri Lanka, 2nd edn. Department of Survey, Colombo
Punyawardena BVR (2011) Country report – Sri Lanka. Workshop on climate change and its impacts on agriculture. Seoul http://www.adbi.org/files/2011.12.13.cpp.day1.sess1.13.country.paper.sri.lanka.pdf
Punyawardena R, Premalal KHMS (2013) Do trends in extreme positive rainfall anomalies in the central highlands of Sri Lanka exist? Ann Sri Lanka Dept Agric 15:1–12
Punyawardena R, Dissanaike T, Mallawathanthri A (2013a) Vulnerability of Sri Lanka to climate change – monograph. Department of Agriculture, Peradeniya
Punyawardena BVR, Mehmood S, Hettiarachchi AK, Iqbal M, Silva SHSA, Goheer A (2013b) Future-climate of Sri Lanka: an approach through dynamic downscaling of ECHAM4 General Circulation Model (GCM). Trop Agric 161:35–50
Rathnabharathi V (2009) Role of traditional paddy in adaptation to climate change impacts. In: Proceedings of the role of community in adaptation to the climate change crisis workshop, Galle, pp 67–80
Senaratne A, Wickramasinghe K (2010) Climate change, local institutions and adaptation experience: the village tank farming community in dry zone Sri Lanka. In: Evans A, Jinapala K (eds) Proceedings of the national conference on water, food security and climate change in Sri Lanka, International Water Management Institute (IWMI), Colombo, 9–11 June 2009, pp 147–156
Sharma G, Rai LK (2010) Climate change and sustainability of agrodiversity in traditional farming of the Sikkim Himalaya. Mountain Institute of India, United Nations University, Tokyo and MacArthur Foundation
Silva P, Dematawewa CMB, Chandrasiri N (2010) Farm animal genetic resources, Chapter 1. In: Silva P (ed) Indigenous animal genetic resources of Sri Lanka – status, potential and opportunities. GEF-UNEP-ILRI -FanGr Asia Project. University of Peradeniya, Peradeniya

Somaratne WG (2010) The System of Rice Intensification (SRI) and food security among the poor: opportunities and constraints. In: Weligamage P, Godaliyadda GGA, Jinapala K (eds) Proceedings of the national conference on water, food security and climate change in Sri Lanka, 9–11 June 2009, International Water Management Institute (IWMI), Colombo, pp 81–91

Titumil RAM, Basak JK (2010) Agriculture and food security in South Asia. A historical analysis and a long run perspective. The Innovators, Dhaka

Upawansa GK (2013) Nava Kekulama method for paddy cultivation. Available at http://goviya.com/nava-kekulam.htm

Weerahewa J, Pushpakumara G, Silva P, Daulagala C, Punyawardena R, Premalal S, Miah G, Roy J, Jana S, Marambe B (2012) Are homegarden ecosystems resilient to climate change? An analysis of the adaptation strategies of homegardeners in Sri Lanka. APN Sci Bull 2:22–27

Weerakoon WMW (2013) Impact of climate change on food security in Sri Lanka. In: HPM Gunasena, HAJ Gunathilake, JMDT Everard, CS Ranasinghe, AD Nainanayake (eds) Proceedings of the international conference on climate change impacts and adaptation for food and environmental security, Colombo, pp 73–86

World Food Programme (2011) Sri Lanka – a food security assessment report. World Food Programme of the United Nations, Colombo

Annex III

CLIMATE RISK COUNTRY PROFILE

SRI LANKA

WORLD BANK GROUP

ADB ASIAN DEVELOPMENT BANK

COPYRIGHT

RIGHTS AND PERMISSIONS

Graphic Design: Circle Graphics, Reisterstown, MD.

ACKNOWLEDGEMENTS

This profile is part of a series of Climate Risk Country Profiles that are jointly developed by the World Bank Group (WBG) and the Asian Development Bank (ADB). These profiles synthesize the most relevant data and information on climate change, disaster risk reduction, and adaptation actions and policies at the country level. The profile is designed as a quick reference source for development practitioners to better integrate climate resilience in development planning and policy making. This effort is co-led by Ana E. Bucher (Senior Climate Change Specialist, WBG) and Arghya Sinha Roy (Senior Climate Change Specialist, ADB).

This profile was written by Alex Chapman (Consultant, ADB), William Davies (Consultant, ADB) and Ciaran Downey (Consultant). Technical review of the profiles was undertaken by Robert L. Wilby (Loughborough University). Additional support was provided by Yunziyi Lang (Climate Change Analyst, WBG), MacKenzie Dove (Senior Climate Change Consultant, WBG), Adele Casorla-Castillo (Consultant, ADB), and Charles Rodgers (Consultant, ADB). This profile also benefitted from inputs of WBG and ADB regional staffs.

Climate and climate-related information is largely drawn from the Climate Change Knowledge Portal (CCKP), a WBG online platform with available global climate data and analysis based on the latest Intergovernmental Panel on Climate Change (IPCC) reports and datasets. The team is grateful for all comments and suggestions received from the sector, regional, and country development specialists, as well as climate research scientists and institutions for their advice and guidance on use of climate-related datasets.

CONTENTS

FOREWORD

Climate change is a major risk to good development outcomes, and the World Bank Group is committed to playing an important role in helping countries integrate climate action into their core development agendas. The World Bank Group (WBG) and the Asian Development Bank (ADB) are committed to supporting client countries to invest in and build a low-carbon, climate-resilient future, helping them to be better prepared to adapt to current and future climate impacts.

Both institutions are investing in incorporating and systematically managing climate risks in development operations through their individual corporate commitments.

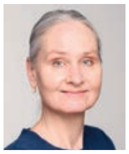
For the World Bank Group: a key aspect of the World Bank Group's Action Plan on Adaptation and Resilience (2019) is to help countries shift from addressing adaptation as an incremental cost and isolated investment to systematically incorporating climate risks and opportunities at every phase of policy planning, investment design, implementation, and evaluation of development outcomes. For all International Development Association and International Bank for Reconstruction and Development operations, climate and disaster risk screening is one of the mandatory corporate climate commitments. This is supported by the World Bank Group's Climate and Disaster Risk Screening Tool which enables all Bank staff to assess short- and long-term climate and disaster risks in operations and national or sectoral planning processes. This screening tool draws up-to-date and relevant information from the World Bank's Climate Change Knowledge Portal, a comprehensive online 'one stop shop' for global, regional, and country data related to climate change and development.

For the Asian Development Bank: its Strategy 2030 identified "tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability" as one of its seven operational priorities. Its Climate Change Operational Framework 2017–2030 identified mainstreaming climate considerations into corporate strategies and policies, sector and thematic operational plans, country programming, and project design, implementation, monitoring, and evaluation of climate change considerations as the foremost institutional measure to deliver its commitments under Strategy 2030. ADB's climate risk management framework requires all projects to undergo climate risk screening at the concept stage and full climate risk and adaptation assessments for projects with medium to high risk.

Recognizing the value of consistent, easy-to-use technical resources for our common client countries as well as to support respective internal climate risk assessment and adaptation planning processes, the World Bank Group's Climate Change Group and ADB's Sustainable Development and Climate Change Department have worked together to develop this content. Standardizing and pooling expertise facilitates each institution in conducting initial assessments of climate risks and opportunities across sectors within a country, within institutional portfolios across regions, and acts as a global resource for development practitioners.

For common client countries, these profiles are intended to serve as public goods to facilitate upstream country diagnostics, policy dialogue, and strategic planning by providing comprehensive overviews of trends and projected changes in key climate parameters, sector-specific implications, relevant policies and programs, adaptation priorities and opportunities for further actions.

We hope that this combined effort from our institutions will spur deepening of long-term risk management in our client countries and support further cooperation at the operational level.



Bernice Van Bronkhorst
Global Director
Climate Change Group
The World Bank Group

Preety Bhandari
Chief of Climate Change and Disaster Risk Management Thematic Group concurrently Director Climate Change and Sustainable Development and Climate Change Department
Asian Development Bank

KEY MESSAGES

- Temperature rise in Sri Lanka is projected to be marginally lower than the global average. Under the highest emissions pathway (RCP8.5) temperatures are projected to rise by 2.9°C–3.5°C by the 2090s, over the 1986–2005 baseline. In contrast, warming of 0.8°C–1.2°C is projected over the same time horizon on the lowest emissions pathway (RCP2.6).
- Rises in minimum temperatures are projected to be faster than rises in average temperatures.
- Sri Lanka faces significant threat from extreme heat, with the number of days surpassing 35°C, potentially rising from a baseline of 20 days to more than 100 days by the 2090s, under emissions pathway RCP8.5.
- Extreme heat threatens human health and living standards, particularly for outdoor laborers in urban areas without adequate cooling systems; this will particularly impact communities in Sri Lanka's northern region. There is also potential for adverse implications to Sri Lanka's large tourism sector.
- Temperature rise is likely to put downward pressure on agricultural yields, including key staples such as rice. This may impact negatively on national and household food security.
- Without adaptative action, the projected increase in the frequency and intensity of extreme precipitation events may put lives, livelihoods, and infrastructure at risk through their link with riverine flooding, flash floods, and landslides.
- Increased incidence of flooding also brings the potential for enhanced disease transmission, an area demanding further research and disaster risk reduction efforts.
- Projected changes are expected to impact on Sri Lanka's poorest and most marginalized communities most strongly, exacerbating poverty and inequality.

COUNTRY OVERVIEW

Sri Lanka is a small island nation lying between 6°N and 10°N latitude and 80°E and 82°E longitude in the Indian Ocean, with a land area of approximately 65,000 square kilometers (km^2). The island consists of a mountainous area in the south-central region and a surrounding coastal plain. The climate of Sri Lanka is wet and warm, ideal for forest growth; almost all of the nation's land area was at one time covered with forests. Over the last century, more than two-thirds of this forest cover, rich in biodiversity, has been removed to accommodate human use. Nonetheless, rich natural resources remain and, alongside its vibrant cultures, contribute to the nation's successful tourism industry.

The economy of Sri Lanka is dominated by the service sector (61.7% of Gross Domestic Product [GDP] as of 2017), with major contributions from trade, transportation, and real estate activities. While the agricultural sector has shrunk in its contribution to GDP (7.8% as of 2017), it remains a significant employer (27% of the labor force as of 2016). Approximately a quarter of Sri Lanka's population are believed to live within the metropolitan area of its commercial capital, Colombo. However, official statistics suggest Sri Lanka's urban population is relatively low, reportedly 19.3% in 2016.[1] As shown in **Table 1**, a large proportion of Sri Lanka's population remains undernourished (22.1% in 2014–2016).

Sri Lanka's high temperatures, unique and complex hydrological regime, and exposure to extreme climate events make it highly vulnerable to climate change. In 2012, the Ministry of Environment submitted its Second National Communication to the UNFCCC (NC2), which highlights key vulnerabilities in the agriculture and water resources sectors, as well as significant risks to human health and in coastal zones.[2] These key climate-related risks were again emphasized in Sri Lanka's Nationally Determined Contribution (NDC) submitted after it signed and ratified the Paris Climate Agreement in 2016. Sri Lanka's NDC outlines the country's commitment to addressing its vulnerability to climate change in line with its commitments to a low carbon pathway through sustainable development efforts.[3]

TABLE 1. Key indicators

Indicator	Value	Source
Population Undernourished[4]	22.1% (2014–2016)	FAO, 2017
National Poverty Rate[5]	4.1% (2016)	ADB, 2018a
Share of Wealth Held by Bottom 20%[6]	7% (2016)	World Bank Group, 2018
Net Annual Migration Rate[7]	–0.47% (2010–2015)	UNDESA, 2017
Infant Mortality Rate (Between Age 0 and 1)[7]	0.82% (2010–2015)	UNDESA, 2017
Average Annual Change in Urban Population[8]	0.03% (2010–2015)	UNDESA, 2018
Dependents per 100 Independent Adults[7]	71 (2015)	UNDESA, 2017
Urban Population as % of Total Population[9]	19.3% (2016)	CBSL, 2018
External Debt Ratio to GNI[10]	59% (2016)	ADB, 2018b
Government Expenditure Ratio to GDP[10]	19.3% (2017)	ADB, 2018b

1 CBSL (2018). Economics and social statistics of Sri Lanka 2018. Central Bank of Sri Lanka. URL: https://www.cbsl.gov.lk/en/publications/other-publications/statistical-publications/economic-and-social-statistics-of-sri-lanka

2 Ministry of Environment (2012). Sri Lanka's Second National Communication on Climate Change. URL: https://unfccc.int/sites/default/files/resource/lkanc2_0.pdf

3 Ministry of Mahaweli Development and Environment (2016). Nationally Determined Contributions, Sri Lanka. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Sri%20Lanka%20First/NDCs%20of%20Sri%20Lanka.pdf

4 FAO, IFAD, UNICEF, WFP, WHO (2017). The state of food security and nutrition in the world. Building Resilience for peace and food security. FAO. Rome. URL: http://www.fao.org/3/a-i7695e.pdf

5 ADB (2018a). Basic Statistics 2018. URL:https://www.adb.org/publications/basic-statistics-2018 [accessed 11/01/19]

6 World Bank Group (2018). Income share held by lowest 20%. URL:https://data.worldbank.org/indicator/SI.DST.FRST.20 [accessed 11/01/19]

7 UNDESA (2017). World Population Prospects 2017. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 11/01/19]

8 UNDESA (2018). World Urbanization Prospects 2018. URL: https://population.un.org/wup/Download/ [accessed 11/01/19]

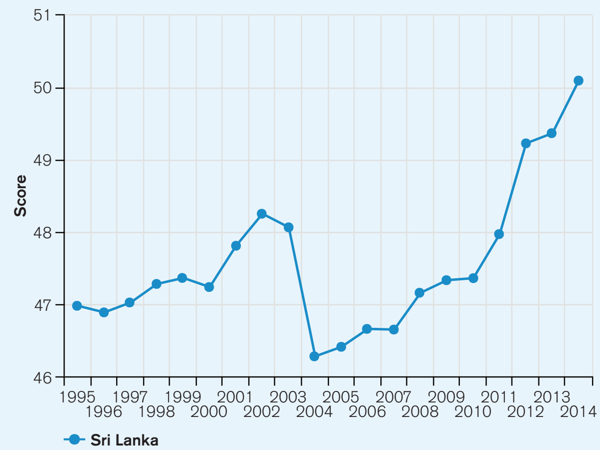
9 CIA (2018). The World Factbook. Central Intelligence Agency. Washington, DC. URL: https://www.cia.gov/library/publications/the-world-factbook/geos/ch.html

10 ADB (2018b). Key Indicators for Asia and the Pacific 2018, 49th Edition. Asian Development Bank. URL: https://www.adb.org/sites/default/files/publication/443671/ki2018.pdf

This document aims to succinctly summarize the climate risks faced by Sri Lanka. This includes rapid onset and long-term changes in key climate parameters, as well as impacts of these changes on communities, livelihoods, and economies, many of which are already underway. This is a high-level synthesis of existing research and analyses, focusing on the geographic domain of Sri Lanka, therefore, potentially excluding some international influences and localized impacts. The core data is sourced from the database sitting behind the World Bank Group's Climate Change Knowledge Portal (CCKP), incorporating climate projections from the Coupled Model Inter-comparison Project Phase 5 (CMIP5). This document is primarily meant for WBG and ADB staff to inform their climate actions and to direct them to many useful sources of secondary data and research.

Due to a combination of political, geographic, and social factors, Sri Lanka is recognized as vulnerable to climate change impacts, ranked 100th out of 181 countries in the 2017 ND-GAIN Index.[11] The ND-GAIN Index ranks 181 countries using a score which calculates a country's vulnerability to climate change and other global challenges as well as their readiness to improve resilience. The more vulnerable a country is, the lower their score, while the more ready a country is to improve its resilience, the higher it will be. Norway has the highest score and is ranked 1st. **Figure 1** is a time-series plot of the ND-GAIN Index showing Sri Lanka's progress

FIGURE 1. The ND-GAIN Index summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. It aims to help businesses and the public sector better prioritize investments for a more efficient response to the immediate global challenges ahead



CLIMATOLOGY

Climate Baseline

Overview

Sri Lanka has two main seasons, the Maha season associated with the northeast monsoon (September–March) and the Yala season associated with the southwest monsoon (May–August). With an average temperature of around 27°C–28°C, Sri Lanka is one of the hottest countries in the world. Sri Lanka's commercial capital, Colombo,

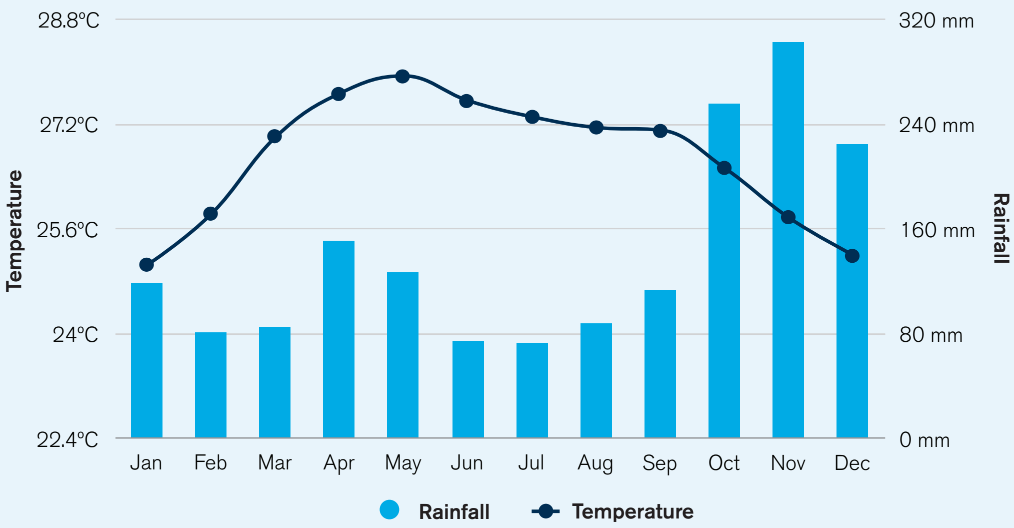
[11] University of Notre Dame (2019). Notre Dame Global Adaptation Initiative. URL: https://gain.nd.edu/our-work/country-index/

experiences average temperatures of 28°C–29°C and, like much of the rest of the country, has little monthly variation in temperature (**Figure 2**). Daily maximum temperatures average around 31°C all year round. The most important factor affecting temperature variations within Sri Lanka is altitude, with considerably lower temperatures experienced in its south-central mountain ranges.

Sri Lanka's topography creates unique rainfall patterns, with notable spatial variation for a country of its size. Sri Lanka's precipitation regime is divided into three zones: the wet zone, intermediate zone, and dry zone. The wet zone, found in the southwest, receives a mean annual rainfall of over 2,500 millimeters (mm), with a strong contribution from the southwest monsoon. The dry zones, found in the south and northwest, receive less than 1,750 mm. The intermediate zones found in the eastern and central regions, receive between 1,750 mm and 2,500 mm, primarily from the northeast monsoon. Areas of the southwestern slopes of the central hills are known to experience as much as 5,000 mm in a year and annual rainfall can vary by more than 1,000–2,000 mm over distances of less than 100 km. All regions receive steady rainfall during the inter-monsoon seasons. **Figure 3** shows the spatial differences of observed temperature and rainfall in Sri Lanka.

Annual Cycle

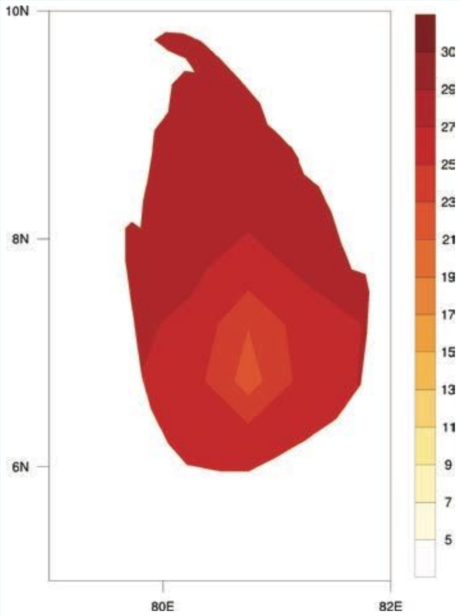
FIGURE 2. Average monthly temperature and rainfall in Sri Lanka (1901–2016)[12]

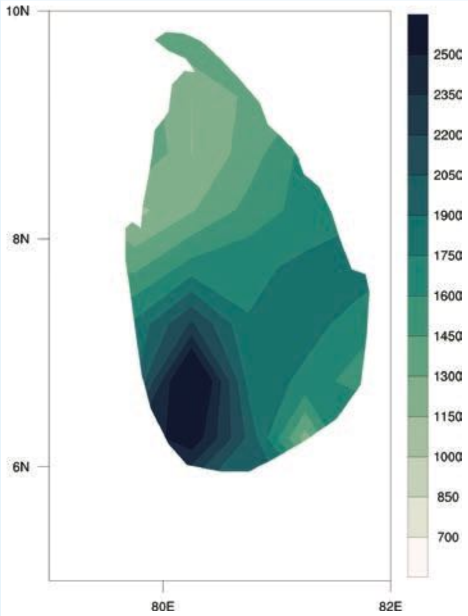


[12] WBG Climate Change Knowledge Portal (CCKP, 2020). Climate Data: Historical. URL: https://climateknowledgeportal.worldbank.org/country/sri-lanka/climate-data-historical

Spatial Variation

FIGURE 3. (Left) annual mean temperature, and (right) annual mean rainfall (mm) in Sri Lanka over the period 1901–2019[13]





Key Trends

Temperature

Analysis of the change seen between the average temperature over 1900–1917 and 2000–2017 suggests Sri Lanka experienced warming of around 0.8°C over the 20th century (based on the Berkeley Earth dataset).[14] This estimate broadly agrees with the temperature rise reported in Sri Lanka's NC2, which estimated 0.16°C of warming per decade between 1961–1990. Temperature rise has accelerated toward the end of the 20th century.[15]

[13] WBG Climate Change Knowledge Portal (CCKP, 2020). Climate Data: Historical. URL: https://climateknowledgeportal.worldbank.org/country/sri-lanka/climate-data-historical

[14] Carbon Brief (2018). Mapped: How every part of the world has warmed – and could continue to. Infographics, Berkeley Dataset. 26 September 2018]. URL: https://www.carbonbrief.org/mapped-how-every-part-of-the-world-has-warmed-and-could-continue-to-warm

[15] Esham, M., & Garforth, C. (2013). Climate change and agricultural adaptation in Sri Lanka: a review. Climate and Development, 5(1), 66–76. URL: https://rsa.tandfonline.com/doi/abs/10.1080/17565529.2012.762333?scroll=top&needAccess=true&journalCode=tcld20#.Xe_wwpNKhBw

Precipitation

Sri Lanka's complex and spatially variable precipitation regime makes estimation of change over time difficult and it should be noted that there is a need to improve the evidence base in this area. A number of studies have attempted to assess the trends in precipitation (see Eriyagama and Smakhtin, 2010).[16] A general trend of decreasing annual precipitation in the latter half of the 20th century has been observed. This decline is estimated at around 7% as compared to the period 1931–1960. This decline in precipitation has been detected during the northeast monsoon season and second inter-monsoon season and is particularly significant in the central regions of the country. It is also observed that the number of consecutive dry days experienced has increased over the 20th century, and the number of consecutive wet days has reduced. A review by Esham and Garforth (2013) also suggests that the variability of climate and the frequency of extreme events has been increasing.[15] Precipitation remains linked to the El Niño Southern Oscillation (ENSO), with El Niño events typically increasing the precipitation associated with the northeast monsoon.[17]

A Precautionary Approach

Studies published since the last iteration of the IPCC's report (AR5), such as Gasser et al. (2018), have presented evidence which suggests a greater probability that earth will experience medium and high-end warming scenarios than previously estimated.[18] Climate change projections associated with the highest emissions pathway (RCP8.5) are presented here to facilitate decision making which is robust to these risks.

Climate Future

Overview

The main data source for the World Bank Group's Climate Change Knowledge Portal (CCKP) is the Coupled Model Inter-comparison Project Phase 5 (CMIP5) models, which are utilized within the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), providing estimates of future temperature and precipitation. Four Representative Concentration Pathways (i.e., RCP2.6, RCP4.5, RCP6.0, and RCP8.5) were selected and defined by their total radiative forcing (cumulative measure of Green House Gas [GHG] emissions from all sources) pathway and level by 2100. In this analysis, RCP2.6 and RCP8.5, the extremes of low and high emissions pathways, are the primary focus: RCP2.6 represents a very strong mitigation scenario, whereas RCP8.5 assumes a business-as-usual scenario. For more information, please refer to the RCP Database.

---

16 Eriyagama, N. and Smakhtin, V. (2010). Observed and Projected Climatic Changes, Their Impacts and Adaptation Options for Sri Lanka: A Review, in Proceedings of the National Conference on Water, Food Security and Climate Change in Sri Lanka, Volume 2, International Water Management Institute, Colombo, 99–117. URL: http://publications.iwmi.org/pdf/H042863.pdf

17 Zubair, L., & Ropelewski, C. F. (2006). The strengthening relationship between ENSO and northeast monsoon rainfall over Sri Lanka and southern India. Journal of Climate, 19(8), 1567–1575. https://doi.org/10.1175/JCLI3670.1. URL: https://journals.ametsoc.org/doi/pdf/10.1175/JCLI3670.1

18 Gasser, T., Kechiar, M., Ciais, P., Burke, E. J., Kleinen, T., Zhu, D., . . . Obersteiner, M. (2018). Path-dependent reductions in CO2 emission budgets caused by permafrost carbon release. Nature Geoscience. URL: https://www.nature.com/articles/s41561-018-0227-0?WT.feed_name=subjects_climate-sciences

For Sri Lanka, models show a trend of consistent warming regardless of emissions scenario. While projections for rainfall are highly variable, trends do show a likely increase in rainfall, and specifically for its central region throughout the century. An increase in intensity for extreme rainfall events is likely. **Tables 2** and **3** below, provide information on temperature projections and anomalies for the four RCPs over two distinct time horizons; presented against the reference period of 1986–2005.

TABLE 2. Projected anomaly (changes °C) for maximum, minimum, and average daily temperatures in Sri Lanka for 2040–2059 and 2080–2099, from the reference period of 1986–2005 for all RCPs. The table shows the median of the CCKP model ensemble and the 10th–90th percentiles in brackets.[19]

	Average Daily Maximum Temperature		Average Daily Temperature		Average Daily Minimum Temperature	
	2040–2059	2080–2099	2040–2059	2080–2099	2040–2059	2080–2099
RCP2.6	0.8 (–0.1, 1.8)	0.9 (0.0, 1.8)	0.9 (0.1, 1.5)	0.9 (0.1, 1.6)	0.9 (0.3, 1.6)	0.9 (0.3, 1.6)
RCP4.5	1.1 (0.1, 2.0)	1.6 (0.5, 2.7)	1.1 (0.4, 1.8)	1.6 (0.7, 2.5)	1.1 (0.5, 1.8)	1.6 (0.5, 2.5)
RCP6.0	1.0 (0.0, 2.0)	1.9 (0.8, 3.1)	1.0 (0.3, 1.7)	1.9 (1.0, 2.9)	1.0 (0.5, 1.7)	2.0 (1.2, 3.0)
RCP8.5	1.5 (0.4, 2.5)	3.2 (1.9, 4.6)	1.5 (0.7, 2.3)	3.2 (2.2, 4.5)	1.6 (0.9, 2.3)	3.4 (2.4, 4.5)

TABLE 3. Projections of average temperature anomaly (°C) in Sri Lanka for different seasons (3-monthly time slices) over different time horizons and emissions pathways, showing the median estimates of the full CCKP model ensemble and the 10th and 90th percentiles in brackets

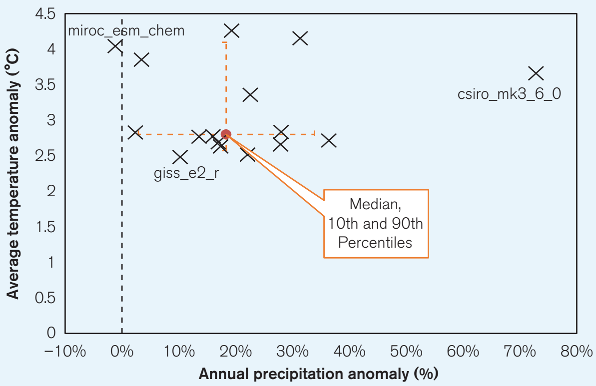
	2040–2059		2080–2099	
	Jun–Aug	Dec–Feb	Jun–Aug	Dec–Feb
RCP2.6	0.9 (0.1, 1.7)	0.8 (0.0, 1.4)	0.9 (0.1, 1.8)	0.8 (0.0, 1.5)
RCP4.5	1.2 (0.5, 1.9)	1.1 (0.3, 1.7)	1.6 (0.7, 2.6)	1.6 (0.7, 2.3)
RCP6.0	1.0 (0.3, 1.9)	1.0 (0.1, 1.5)	1.9 (1.1, 3.1)	1.9 (0.8, 2.6)
RCP8.5	1.5 (0.8, 2.3)	1.5 (0.6, 2.1)	3.4 (2.2, 4.6)	3.1 (2.1, 4.1)

[19] WBG Climate Change Knowledge Portal (CCKP, 2020). Climate Data: Historical. URL:https://climateknowledgeportal.worldbank.org/country/sri-lanka/climate-data-historical.

Model Ensemble

Climate projections presented in this document are derived from datasets available through the CCKP, unless otherwise stated. These datasets are processed outputs of simulations performed by multiple General Circulation Models (GCM) (for further information see Flato et al., 2013).[20] Collectively, these different GCM simulations are referred to as the 'model ensemble'. Due to the differences in the way GCMs represent the key physical processes and interactions within the climate system, projections of future climate conditions can vary widely between different GCMs, this is particularly the case for rainfall-related variables and at national and local scales. The range of projections from 16 GCMs for annual average temperature change and annual precipitation change in Sri Lanka under RCP8.5 is shown in **Figure 4**. Spatial representation of future projections of annual temperature and precipitation for mid and late century under RCP8.5 are presented in **Figure 5**.

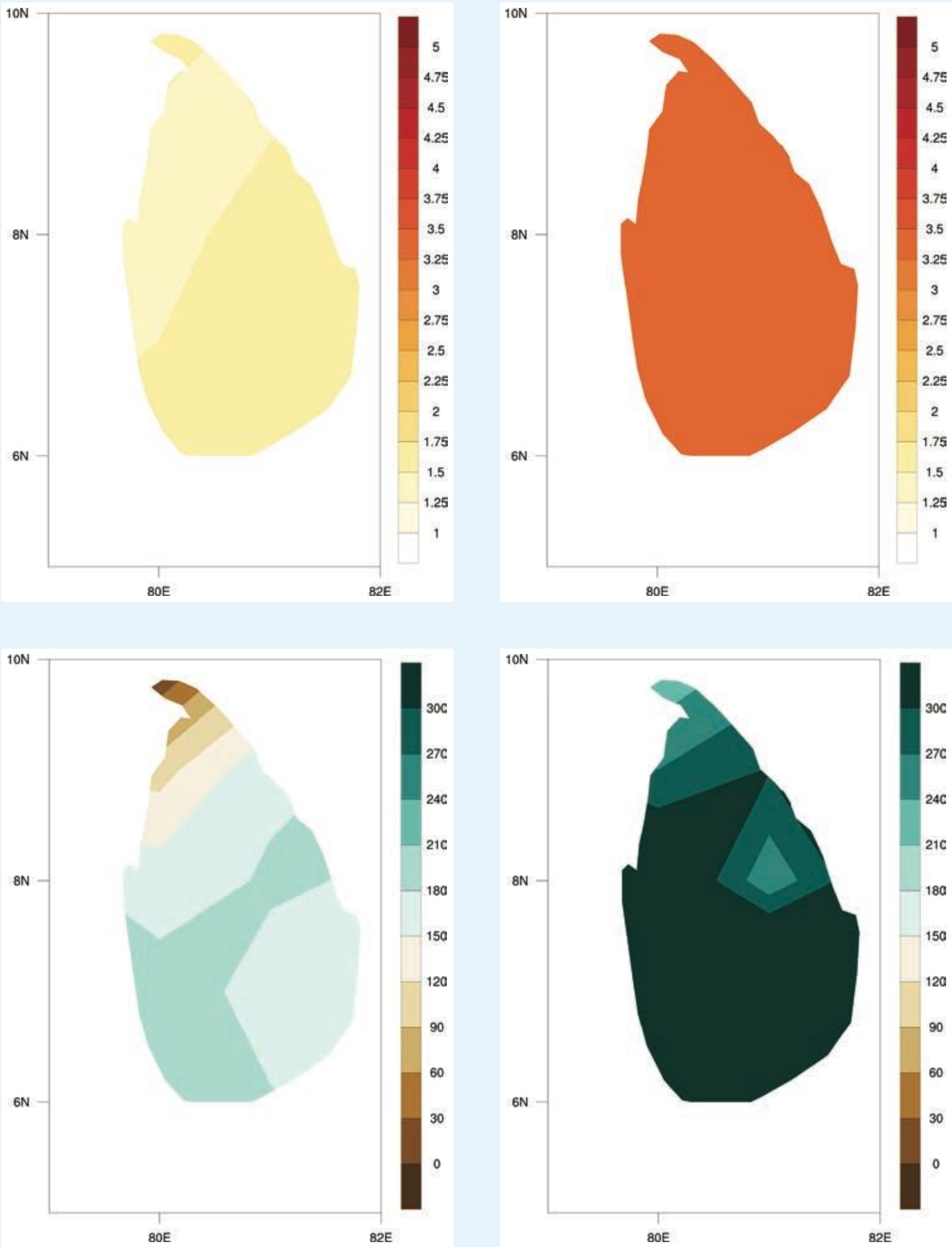
FIGURE 4. 'Projected average temperature anomaly' and 'projected annual rainfall anomaly' in Sri Lanka. Outputs of 16 models within the ensemble simulating RCP8.5 over the period 2080–2099. Models shown represent the subset of models within the ensemble which provide projections across all RCPs and, therefore, are most robust for comparison. Three outlier models are labelled



[20] Flato, G., Marotzke, J., Abiodun, B., Braconnot, P., Chou, S. C., Collins, W., . . . Rummukainen, M. (2013). Evaluation of Climate Models. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 741–866. URL: http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf

Spatial Variation

FIGURE 5. CMIP5 ensemble projected change (32 GCMs) in annual temperature (top) and precipitation (bottom) by 2040–2059 (left) and by 2080–2090 (right) relative to 1986–2005 baseline under RCP8.5[21]



[21] WBG Climate Change Knowledge Portal (CCKP, 2020). Sri Lanka Climate Data. Projections. URL: https://climateknowledgeportal.worldbank.org/country/sri-lanka/climate-data-projections

Temperature

Projections of future temperature change are presented in three primary formats. Shown in **Table 2** are the changes (anomalies) in daily maximum and daily minimum temperatures over the given time period, as well as changes in the average temperature. **Figures 6** and **7** display the annual and monthly average temperature projections. While similar, these three indicators can provide slightly different information. Monthly and annual average temperatures are most commonly used for general estimation of climate change, but the daily maximum and minimum can explain more about how daily life might change in a region, affecting key variables such as the viability of ecosystems, health impacts, productivity of labor, and the yield of crops, which are often disproportionately influenced by temperature extremes.

Average temperature rise in Sri Lanka is expected to be lower than the rise in global temperatures, and are projected to reach approximately 3.2°C by the 2090s according to the CCKP model ensemble under emissions pathway RCP8.5, compared to the projected global rise of 3.7°C. Maximum and minimum temperatures are projected to rise faster than the average, but still remain below global averages. Statistically downscaled projections from the KNMI Climate Explorer, which operate on a slightly finer spatial resolution, show a rise in the region of 3.5°C under RCP8.5, and 1.2°C under RCP2.6 by the 2090s.[22] Projected rises are very likely to push ambient temperatures over 30°C on a much more regular basis, and to considerably increase the frequency of temperatures over 35°C.

FIGURE 6. Historic and projected average annual temperature in Sri Lanka under RCP2.6 (blue) and RCP8.5 (red) estimated by the model ensemble. Shading represents the standard deviation of the model ensemble[23]

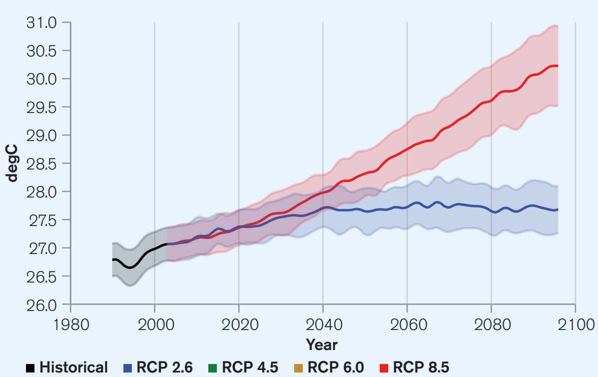
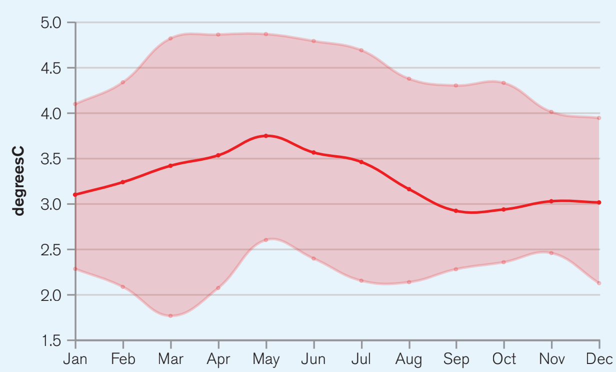


FIGURE 7. Projected change (anomaly) in monthly temperature, shown by month, for Sri Lanka for the period 2080–2099 under RCP8.5. The value shown represents the median of the model ensemble with the shaded areas showing the 10th–90th percentiles[24]



The model ensemble's projections of temperature rise are highly seasonal. Temperatures could rise faster in the months March to July than August to February. The difference in median average temperature rise between May and October being as much as 20%–25% by the 2090s under all emissions pathways.

---

[22] KNMI (2019). Climate Explorer CMIP5 Projections. URL: https://climexp.knmi.nl/start.cgi

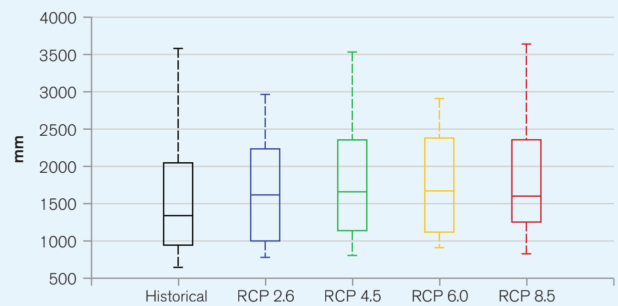
[23] WBG Climate Change Knowledge Portal (CCKP, 2020). Sri Lanka. Agriculture Interactive Indicator Dashboard: URL: https://climatedata.worldbank.org/CRMePortal/web/agriculture/crops-and-land-management?country=LKA&period=2080-2099

[24] WBG Climate Change Knowledge Portal (CCKP, 2020). Sri Lanka. Agriculture Interactive Indicator Dashboard: URL: https://climatedata.worldbank.org/CRMePortal/web/agriculture/crops-and-land-management?country=LKA&period=2080-2099

Precipitation

Climate model projections of future rainfall are generally less reliable than temperature projections, especially for island nations. This is due in part to coarse spatial resolution, which fails to capture local processes that drive rainfall dynamics such as feedbacks and convection, or the presence of land surfaces. The CCKP model ensemble suggests increases in median annual rainfall under all emissions pathways. However, uncertainty in this estimate is high (as seen in the interquartile range shown in **Figure 8**). This projected trend is counter to the observed historical drying trend. While the majority of climate models agree on this trend, the majority of projections sit within the range of historical baseline variability.

FIGURE 8. Boxplots showing the projected average annual precipitation for Sri Lanka in the period 2080–2099[23]



While considerable uncertainty surrounds projections of local, long-term future precipitation trends, some global trends are evident. The intensity of sub-daily extreme rainfall events appears to be increasing with temperature, a finding supported by evidence from different regions of Asia.[25] The volume of water deposited during future 5-day heavy rainfall events is expected to increase, but again, the variability in projections is high. Certainty is highest under RCP6.0 and RCP8.5 where increases in the range of 5%–30% are plausible by the 2080s. Precipitation changes are likely to depend on how climate change affects the dynamics of the two monsoon seasons affecting Sri Lanka. Jayasankar et al. (2015) attempt to provide more robust analysis of changes in Indian Summer Monsoon rainfall through the creation of sub-groups of GCMs and statistically analyzing the performance of those groups.[26] The best performing sub-group point toward a slight reduction in the frequency of light precipitation events which is offset by an increase in the frequency of high and extreme precipitation events, leading to a net increase in average daily monsoon precipitation of 0.74 ± 0.36 mm/day.[27] Downscaling has been conducted using a very limited set of GCMs, but has thus far pointed to either increases in, or no change to, annual rainfall, alongside increased intensity of extreme rainfall events.[28,29] Further research and model downscaling work is required to constrain and localize potential changes to Sri Lanka across a wider set of global climate models.

---

[25] S. Westra, H. J. Fowler, J. P. Evans, L. V. Alexander, P. Berg, F. Johnson, E. J. Kendon, G. Lenderink, N. M. R. (2014). Future changes to the intensity and frequency of short-duration extreme rainfall. Reviews of Geophysics, 52, 522–555. URL: https://www.jstage.jst.go.jp/article/hrl/10/4/10_139/_pdf

[26] Jayasankar, C., Surendran, S., Rajendran, K. (2015). Robust signal of future projections of Indian Summer Monsoon rainfall by IPCC AR5 climate models: Role of seasonal cycle and interannual variability. Geophysical Research Letters: 42: 3513–3520. URL: https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2015GL063659

[27] Sharmila, S., Joseph, S., Sahai, A.K., Abhilash, S., Chattopadhyay, R. (2015). Future projection of Indian summer monsoon variability under climate change scenario: An assessment from CMIP5 climate models. Global and Planetary Change: 124: 62–78. URL: https://ui.adsabs.harvard.edu/abs/2015GPC . . . 124 . . . 62S/abstract

[28] Dorji, S., Herath, S., & Mishra, B. K. (2017). Future Climate of Colombo Downscaled with SDSM-Neural Network. Climate, 5(1). URL: https://www.mdpi.com/2225-1154/5/1/24

[29] Silva, G. De, Weerakoonb, S., & Herath, S. (2016). Event Based Flood Inundation Mapping Under the Impact of Climate Change: A Case Study in Lower Kelani River Basin, Sri Lanka. Hydrology: Current Research, 7(1), 7–10. URL: https://www.omicsonline.org/open-access/event-based-flood-inundation-mapping-under-the-impact-of-climatechange-a-case-study-in-lower-kelani-river-basin-sri-lanka-2157-7587-1000228.php?aid=69230

Sri Lanka faces moderate disaster risk levels, ranked 97th out of 191 countries by the 2019 INFORM Risk Index[30] (**Table 4**). Sri Lanka has moderate exposure to flooding (ranked 56th), including riverine and flash flooding. Sri Lanka also has some exposure to tropical cyclones and their associated hazards (ranked 45th). Drought exposure is slightly lower (ranked 76th). Sri Lanka's overall ranking on the INFORM risk index is somewhat mitigated by its comparatively high coping capacity score. Landslide hazard is present in many parts of Sri Lanka, but is not explicitly captured by the INFORM risk index. The section which follows analyzes climate change influences on the exposure component of risk in Sri Lanka. As seen in **Figure 1**, the ND-GAIN Index presents an overall picture of a country's vulnerability and capacity to improve its resilience. In contrast, the Inform Risk Index identifies specific risks across a country to support decisions on prevention, preparedness, response and a country's overall risk management.

TABLE 4. Selected indicators from the INFORM 2019 Index for Risk Management for Sri Lanka. For the sub-categories of risk (e.g., "Flood") higher scores represent greater risks. Conversely the most at-risk country is ranked 1st. The average score across all countries is shown in brackets

Flood (0–10)	Tropical Cyclone (0–10)	Drought (0–10)	Vulnerability (0–10)	Lack of Coping Capacity (0–10)	Overall Inform Risk Level (0–10)	Rank (1–191)
6.1 [4.5]	3.6 [1.7]	3.6 [3.2]	3.4 [3.6]	4.1 [4.5]	3.6 [3.8]	97

Heatwaves

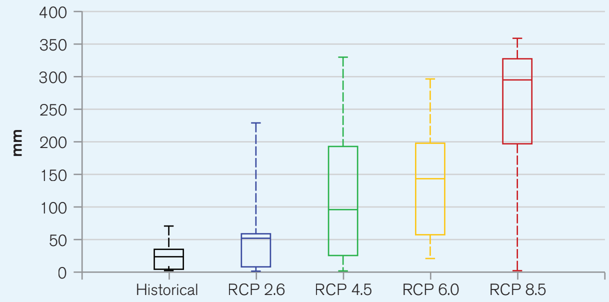
Sri Lanka regularly experiences very high maximum temperatures, with an average monthly maximum of around 30°C and an average maximum of 32°C. The current probability of a heat wave (defined as a period of 3 or more days where the daily temperature is above the long-term 95th percentile of daily mean temperature) is around 3%. One study by IWMI suggested that around 23% of Sri Lanka's population were exposed to hazardous heatwaves during the period 2001–2013 (defined here as an anomaly of +6°C).[31] The CCKP model ensemble projects significant future increases in the annual probability of a heatwave under all emissions pathways in Sri Lanka. These projected increases primarily reflect the general warming trend, as well as increasing variability in climate, both of which amplify heatwave probability when the historical period (1986–2005) is held as the baseline. While heatwaves refer to the periodic occurrence of exceptionally high temperatures, the incidence of permanent (chronic) heat stress is likely to increase significantly in Sri Lanka under all emissions pathways. This threat is highlighted in

[30] European Commission (2019). INFORM Index for Risk Management. Sri Lanka Country Profile. URL:https://drmkc.jrc.ec.europa.eu/inform-index/Countries/Country-Profile-Map

[31] Amarnath, G.; Alahacoon, N.; Smakhtin, V.; Aggarwal, P. (2017). Mapping multiple climate-related hazards in South Asia. Colombo, Sri Lanka: International Water Management Institute (IWMI). 41p. (IWMI Research Report 170). URL: http://www.iwmi.cgiar.org/Publications/IWMI_Research_Reports/PDF/pub170/rr170.pdf

Figure 9, which shows the significant projected increase in the number of days surpassing the Heat Index of 35°C by the 2090s. Im et al. (2017) identify northern Sri Lanka as a hotspot of exposure to extreme heat even under lower emissions pathways.[32]

FIGURE 9. Historical (1986–2005) and projected (2080–2099) average annual number of days with Heat Index > 35°C under four emissions pathways[23]

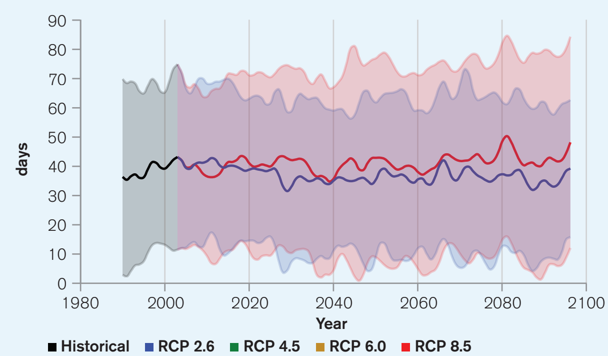


Drought

Two primary types of drought may affect Sri Lanka, meteorological (usually associated with a precipitation deficit) and hydrological (usually associated with a deficit in surface and subsurface water flow, potentially originating in the region's wider river basins). At present, Sri Lanka faces an annual probability of severe meteorological drought of around 4%, as defined by the Standardized Precipitation Evaporation Index (SPEI) of less than –2. One study suggested that between 2001–2013, approximately 10% of Sri Lanka's population was exposed to drought (in this case, drought was categorized as a Normalized Difference Drought Index of >0.6).[31]

Naumann et al. (2018) provide a global overview of changes in drought conditions under different warming scenarios.[33] The research suggests that in South Asia, there could be an increase in the frequency of drought events, with what is currently a 1-in-100-year event returning approximately every 40 to 50 years under 1.5°C–2°C of warming, and every 20 years under 3°C of warming. In contrast, no significant change to severe drought probability is projected by the CCKP model ensemble. **Figure 10** shows the number of consecutive dry days through the end of the century. The difference in projections may relate to the coarse spatial resolution of the model ensemble and the model choices made by the researchers. Global models do not capture the dynamics of precipitation in Sri Lanka, which can vary dramatically over small distances. Further research and downscaling of global models are urgently required to constrain future drought projections in Sri Lanka. Future drought risk, particularly hydrological and agricultural drought, will also depend to a great extent on development, and water and land management practices in Sri Lanka over coming decades.

FIGURE 10. Time Series showing the maximum number of consecutive dry days in Sri Lanka through 2080–2099, under RCP2.6 (blue) and RCP8.5 (red) estimated by the model ensemble. Shading represents the standard deviation of the model ensemble[23]



[32] Im, E. S., Pal, J. S., & Eltahir, E. A. B. (2017). Deadly heat waves projected in the densely populated agricultural regions of South Asia. Science Advances, 3(8), 1–8. https://advances.sciencemag.org/content/3/8/e1603322

[33] Naumann, G., Alfieri, L., Wyser, K., Mentaschi, L., Betts, R. A., Carrao, H., . . . Feyen, L. (2018). Global Changes in Drought Conditions Under Different Levels of Warming. Geophysical Research Letters, 45(7), 3285–3296. URL: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2017GL076521

Floods

Sri Lanka is affected by multiple forms of flooding. These can be summarized as river flooding, flash (or pluvial) flooding, and coastal flooding. In addition to their direct impacts, flood events have known relationships with other hazards, such as landslides as well as the spread of disease. The World Resources Institute's AQUEDUCT Global Flood Analyzer can be used to establish a baseline level of river flood exposure.[34] As of 2010, assuming protection for up to a 1-in-25-year event, the population annually affected by river flooding in Sri Lanka is estimated at 59,000 people and the expected annual impact on GDP is estimated at $267 million. The United Nations Office for Disaster Risk Reduction (UNDRR), formerly the United Nations International Strategy for Disaster Reduction (UNISDR), suggested floods are currently the largest contributor to Sri Lanka's average annual losses from disasters of approximately $140 million per year.[35] Development and climate change are both likely to increase these figures. By the 2030s, this is expected to increase the annually affected population by 26,000 people, and annual GDP by $338 million under RCP8.5 (AQUEDUCT Scenario B).

Work by Paltan et al. (2018) demonstrates that even under lower emissions pathways coherent with the Paris Climate Agreement, almost all Asian countries face an increase in the frequency of extreme river flows.[36] What would historically have been a 1-in-100-year flow, could become a 1-in-50-year or 1-in-25-year event in most of South, Southeast, and East Asia. There is good agreement among models on this trend. Willner et al. (2018) suggest this increase in flows could lead to an increase in the population affected by an extreme flood of 70,000–560,000 people (**Table 5**).[37]

TABLE 5. Estimated number of people in Sri Lanka affected by an extreme river flood (extreme river flood is defined as being in the 90th percentile in terms of numbers of people affected) in the historic period 1971–2004 and the future period 2035–2044. Figures represent an average of all four RCPs and assume present day population distributions[37]

Estimate	Population Exposed to Extreme Flood (1971–2004)	Population Exposed to Extreme Flood (2035–2044)	Increase in Affected Population
16.7 Percentile	385,942	943,081	557,139
Median	930,866	1,111,418	180,552
83.3 Percentile	1,105,180	1,179,366	74,186

Periods of intense precipitation can result in flash flooding and landslide events in Sri Lanka, leading to loss of life, livelihoods, and infrastructure. Indeed, around 20% of the nation's surface area is estimated to be exposed to landslide events and these events are reportedly the third most frequently occurring hazard, behind flood and drought.[38] Past research has shown that shifts in the precipitation regime toward more intense extreme events

[34] WRI (2018). AQUEDUCT Global Flood Analyzer. URL: https://floods.wri.org/# [accessed: 22/11/2018]

[35] UNISDR (2014). PreventionWeb: Basic country statistics and indicators. URL: https://www.preventionweb.net/countries [accessed 14/08/2018]

[36] Paltan, H., Allen, M., Haustein, K., Fuldauer, L., & Dadson, S. (2018). Global implications of 1.5°C and 2°C warmer worlds on extreme river flows. Environmental Research Letters, 13. URL: https://iopscience.iop.org/article/10.1088/1748-9326/aad985/pdf

[37] Willner, S., Levermann, A., Zhao, F., Frieler, K. (2018). Adaptation required to preserve future high-end river flood risk at present levels. Science Advances: 4:1. URL: https://advances.sciencemag.org/content/4/1/eaao1914

[38] Wickramaratne, S., Ruwanpura, J., Ranasinghe, U., Walawe-Durage, S., Adikariwattage, V., & Wirasinghe, S. C. (2012). Ranking of natural disasters in Sri Lanka for mitigation planning. International Journal of Disaster Resilience in the Built Environment, 3(2), 115–132. URL: https://www.emerald.com/insight/content/doi/10.1108/17595901211245198/full/html

have driven increased landslide risk over the late 20th and early 21st centuries.[39] While projections of future average annual precipitation hold uncertainty, there is some confidence that extremes of precipitation at the daily and sub-daily level will increase, likely leading to an increase in landslide risk. Further research is needed.

Cyclones

Climate change is expected to influence cyclone hazards in complex ways which remain poorly understood. Known risks include the action of sea-level rise to enhance the damage caused by cyclone-induced storm surges, and the possibility of increased windspeed and precipitation intensity. Modelling of climate change impacts on cyclone intensity and frequency conducted across the globe points to a general trend of reduced cyclone occurrences, but increased intensity and frequency of the most extreme events.[40] Further research is required to better understand potential changes in cyclone seasonality and routes, and the potential for cyclone hazards to be experienced in unprecedented locations. While records show cyclone frequency in Sri Lanka has a declining trend over the 20th century, Balaguru et al. (2014) report increased intensity of tropical cyclone activity in the Bay of Bengal in 1981–2010, emphasizing that disaster risk reduction remains a priority.[41]

CLIMATE CHANGE IMPACTS

Natural Resources

Water

Sri Lanka is exposed to moisture-laden winds from the southwest and the northeast. The topography of the country (the highland massif) is a major determinant of water resources of the island in the south-central region as is its location across the passage of monsoonal winds. These moisture-laden monsoonal winds are intercepted by the hills in the central region leading to a unique rainfall pattern. Despite its favorable geographic position, the country has widespread areas of water scarcity and a large part of the country experiences intermittent droughts, sometimes extending over several months. Conversely, the coastal areas often get inundated by flood-waters from the highlands.

Sri Lanka's surface water is sourced water from high watersheds and transported by 103 distinct natural river basins that cover 90% of the island, transporting approximately 3.3 million hectare-meters of water each year; the remaining 94 small coastal basins contribute only marginally to water resources. River basins originating in the wetter parts of

---

[39] Ratnayake, U., & Herath, S. (2005). Changing rainfall and its impact on landslides in Sri Lanka. Journal of Mountain Science, 2(3), 218–224. URL: https://link.springer.com/content/pdf/10.1007/BF02973195.pdf

[40] Walsh, K., McBride, J., Klotzbach, P., Balachandran, S., Camargo, S., Holland, G., Knutson, T., Kossin, J., Lee, T., Sobel, A., Sugi, M. (2015). Tropical cyclones and climate change. WIREs Climate Change: 7: 65–89. URL: https://onlinelibrary.wiley.com/doi/epdf/10.1002/wcc.371

[41] Balaguru, K., Taraphdar, S., Leung, L. R., & Foltz, G. R. (2014). Increase in the intensity of postmonsoon Bay of Bengal tropical cyclones. Geophysical Research Letters, 41(10), 3594–3601. URL: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2014GL060197

the hill country are perennial, while the majority of those in the dry zone are seasonal.[42] The country's water resources are critical for many development sectors and for human use. Access to water sources is reasonably good, with an estimated 92.3% of the population having access to at least a basic water supply in 2015.[43] However, ADB's 2016 Water Outlook identified potential weaknesses in Sri Lanka's existing economic and household water security.[44]

The overall impacts of climate change on the water sector are likely to have adverse effects for agricultural water supply, energy generation, human health, and human settlements. As of 2019, a major hindrance to effective water governance and planning was the level of uncertainty, and lack of spatial specificity associated with all water-related projections. In what is a highly spatially variable climate, and with noteworthy social vulnerabilities, further research is urgently required to improve understanding of potential future issues.

Coastal Zone

Sea-level rise threatens significant physical changes to coastal zones around the world. Global mean sea-level rise was estimated in the range of 0.44–0.74 meters (m) by the end of the 21st century by the IPCC's Fifth Assessment Report,[45] however, some studies published more recently have highlighted the potential for more significant rises (**Table 6**). Sri Lanka has a moderate level of vulnerability to slow onset sea-level rise impacts, but has been identified as having particularly high vulnerability to the combined impacts of storm surge and sea-level rise.[46] While the total population likely to be exposed to permanent flooding by 2070–2100 is relatively low at 66,000 people without adaptation actions (**Table 7**), the population exposed to a 1-in-100-year coastal flood induced by storm surge is relatively high. It is estimated that by the 2030s, approximately 230,000–400,000 people could reside in exposed floodplains, growing to 400,000 to 500,000 by the 2060s.[47] These estimates assume modest sea-level rise of 10 centimeters (cm) by 2030 and by 21 cm by 2060.

In addition to the increased risk of rapid-onset disaster events, sea-level rise is already impacting the lives and livelihoods of Sri Lankans along the coast through the salinization of soils and groundwater in the coastal zones. Studies have documented the abandonment of coastal agriculture and degradation of water sources used for human consumption.[48]

---

42 Ministry of Environment (2012). Sri Lanka's Second National Communication on Climate Change. URL: https://unfccc.int/sites/default/files/resource/lkanc2_0.pdf

43 Water Aid (2018). The State of the World's Water 2018. URL: https://washmatters.wateraid.org/sites/g/files/jkxoof256/files/The%20Water%20Gap%20State%20of%20Water%20report%20lr%20pages.pdf

44 ADB (2016). Asian Water Development Outlook 2016: Strengthening Water Security in Asia and the Pacific. Asian Development Bank. URL: https://www.adb.org/sites/default/files/publication/189411/awdo-2016.pdf

45 Church, J. A., Clark, P. U., Cazenave, A., Gregory, J. M., Jevrejeva, S., Levermann, A., . . . Unnikrishnan, A. S. (2013). Sea level change. In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (1137–1216). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. URL: https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter13_FINAL.pdf

46 Dasgupta, S., Laplante, B., Murray, S., & Wheeler, D. (2011). Exposure of developing countries to sea-level rise and storm surges. Climatic Change, 106(4), 567–579. URL: https://link.springer.com/content/pdf/10.1007/s10584-010-9959-6.pdf

47 Neumann, B., Vafeidis, A. T., Zimmermann, J., & Nicholls, R. J. (2015). Future coastal population growth and exposure to sea-level rise and coastal flooding—A global assessment. PLOS ONE, 10(3). URL: https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0118571&type=printable

48 Perera, M. D. N. D., Ranasinghe, T. K. G. P., Piyadasa, R. U. K., & Jayasinghe, G. Y. (2018). Risk of seawater intrusion on coastal community of Bentota river basin Sri Lanka. Procedia Engineering, 212, 699–706. URL: https://www.sciencedirect.com/science/article/pii/S1877705818301085

TABLE 6. Estimates of global mean sea-level rise by rate and total rise compared to 1986–2005 including likely range shown in brackets, data from Chapter 13 of the IPCC's Fifth Assessment Report with upper-end estimates based on higher levels of Antarctic ice-sheet loss from Le Bars et al. 2017[49]

Scenario	Rate of Global Mean Sea-Level Rise in 2100	Global Mean Sea-Level Rise in 2100 Compared to 1986–2005
RCP2.6	4.4 mm/yr (2.0–6.8)	0.44 m (0.28–0.61)
RCP4.5	6.1 mm/yr (3.5–8.8)	0.53 m (0.36–0.71)
RCP6.0	7.4 mm/yr (4.7–10.3)	0.55 m (0.38–0.73)
RCP8.5	11.2 mm/yr (7.5–15.7)	0.74 m (0.52–0.98)
Estimate Inclusive of High-End Antarctic Ice-Sheet Loss		1.84 m (0.98–2.47)

TABLE 7. The average number of people experiencing flooding per year in the coastal zone in the period 2070–2100 under different emissions pathways (assumed medium ice-melt scenario) and adaptation scenarios for Sri Lanka[50]

Scenario	Without Adaptation	With Adaptation
RCP2.6	15,290	30
RCP8.5	65,610	70

Economic Sectors

Agriculture and Fisheries

The agricultural sector in Sri Lanka includes both a domestic market and an export market. Rice is the major food crop grown, with cultivation limited to two primary seasons—Yala (May to August) and Maha (September to March). Production is highest in the Maha season, with the harvested area nearly 50% lower in the Yala season. As of 2014, approximately 74% of the harvested paddy area was supported by either a major or minor irrigation scheme, with the remaining 26% under a rainfed scheme.[51] Other key crops include tea, rubber, and coconut, which collectively are cultivated over an area comparable with paddy rice (ca. 600,000–700,000 ha). However, food crops such as pulses, oil crops, fiber crops, other cereals, yams, vegetables, and others are grown as rotation crops, for household use or for sale in local markets. The agriculture and forestry sectors rely on both traditional and modern technologies; generally, neither sector is highly mechanized.

Climate change could influence food production via direct and indirect effects on crop growth processes. Direct effects include alterations to carbon dioxide availability, precipitation, and temperatures. Indirect effects include impacts on water resource availability and seasonality, soil organic matter transformation, soil erosion, changes

---

[49] Le Bars, D., Drijhout, S., de Vries, H. (2017). A high-end sea level rise probabilistic projection including rapid Antarctic ice sheet mass loss. Environmental Research Letters: 12:4. URL: https://iopscience.iop.org/article/10.1088/1748-9326/aa6512

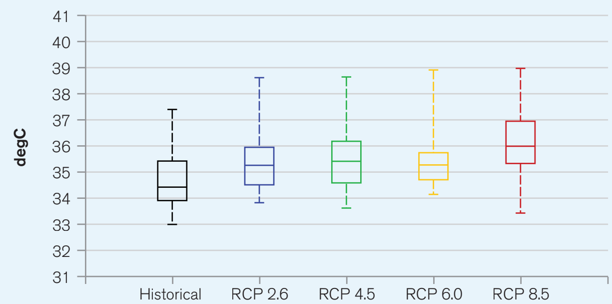
[50] UK Met Office (2014). Human dynamics of climate change: Technical Report. Met Office, UK Government. URL: https://www.metoffice.gov.uk/weather/learn-about/climate-and-climate-change/climate-change/impacts/human-dynamics/index

[51] Department of Census and Statistics (2015). Paddy: Extent sown and harvested by irrigation scheme and season, 2006–2014. URL: http://www.statistics.gov.lk/Abstract2015/CHAP5/5.3.pdf [accessed 11/12/2018]

in pest and disease profiles, the arrival of invasive species, and decline in arable areas due to the submergence of coastal lands and desertification. Globally, these impacts are also expected to damage key staple crop yields, even on lower emissions pathways. Tebaldi and Lobell (2018) estimate that 5% and 6% declines in global wheat and maize yields, respectively, are possible even if the Paris Climate Agreement is met and warming is limited to 1.5°C.[52] Shifts in the optimal and viable spatial ranges of certain crops are also inevitable, though the extent and speed of those shifts remains dependent on the emissions pathway.

Rice is a staple food item in Sri Lanka, crucial to national food security and the livelihoods and nutrition of an estimated 32% of the population.[53] Increases in temperature during the rice growing season have been shown to have negative consequences for yields, outweighing the benefits of increased carbon dioxide (CO_2) concentrations. In particular, rice has been observed to have vulnerability to elevated night time minimum temperatures.[54] Sri Lanka faces very significant increases in minimum temperatures under all emissions pathways (**Figure 11**). Work by Zubair et al. (2015) based on a subset of five climate models suggests that under RCP8.5, yields could decline in both growing seasons.[53] By the 2060s, yields are projected to decline in the range of 12%–19% in the Maha season and 27%–41% in the Yala season. In the context of high local dependence on rice, this is also projected to increase poverty rates, in the range of 12%–26%. A review by Esham and Garforth (2013) also highlights the high sensitivity of other key crops, such as coconut, tea, and rubber, to temperature and precipitation variability, with notable risks to higher temperatures and periods of low rainfall.[15]

FIGURE 11. Historical and projected model ensemble estimates of daily maximum temperatures in 2040–2059 under four emissions pathways in Sri Lanka[23]



Sri Lanka has a notably high dependency on fisheries for its national protein intake. While management approaches and trade practices remain the largest influence on the health of fisheries, research also links productivity to climate change. Rising temperatures and ocean acidification are expected to restructure coastal shelf fisheries upon which many households depend. Barange et al. (2014) identify Sri Lanka as one of the most at-risk nations on earth, projecting a potential decline in fish catch due to climate change of around 20% by the 2050s (this estimate based on the SRES scenario A1B).[55]

---

52 Tebaldi, C., & Lobell, D. (2018). Differences, or lack thereof, in wheat and maize yields under three low-warming scenarios. Environmental Research Letters: 13: 065001. URL: https://iopscience.iop.org/article/10.1088/1748-9326/aaba48

53 Zubair, L., Nissanka, S. P., Weerakoon, W. M. W., Herath, D. I., Karunaratne, A. S., Prabodha, A. S. M., . . . McDermid, S. P. (2015). Climate change impacts on rice farming systems in northwestern Sri Lanka. In Handbook of Climate Change and Agroecosystems: The Agricultural Model Intercomparison and Improvement Project (AgMIP), Part 2. ICP Series on Climate Change Impacts, Adaptation, and Mitigation Vol. 3 (Vol. 2, 315–352). URL: https://pubs.giss.nasa.gov/abs/zu02000c.html

54 Welch, J. R., Vincent, J. R., Auffhammer, M., Moya, P. F., Dobermann, A., & Dawe, D. (2010). Rice yields in tropical/subtropical Asia exhibit large but opposing sensitivities to minimum and maximum temperatures. Proceedings of the National Academy of Sciences, 107(33), 14562–14567. URL: https://www.pnas.org/content/107/33/14562

55 Barange, M., Merino, G., Blanchard, J. L., Scholtens, J., Harle, J., Allison, E. H., . . . Jennings, S. (2014). Impacts of climate change on marine ecosystem production in societies dependent on fisheries. Nature Climate Change, 4(3). URL: https://www.nature.com/articles/nclimate2119.pdf

A further, and perhaps lesser appreciated, influence of climate change on agricultural production is through its impact on the health and productivity of the labor force. Work by Dunne et al. (2013) suggests that global labor productivity during peak months has already dropped by 10% as a result of warming, and that a decline of up to 20% might be expected by the 2050s under RCP8.5.[56] In combination, it is highly likely that the above processes could have a considerable impact on national food production and consumption patterns both through direct impacts on internal agricultural operations, and through impacts on the global supply chain.

Urban and Energy

Research has established a reasonably well constrained relationship between heat stress and labor productivity, household consumption patterns, and (by proxy) household living standards.[57] The impact of an increase in temperature on these indicators depends on whether the temperature rise moves the ambient temperature closer to, or further away from, the optimum temperature range. The optimum range can vary depending on local conditions and adaptations.

The effects of temperature rise and heat stress in urban areas are increasingly compounded by the phenomenon of the Urban Heat Island (UHI) effect. Dark surfaces, residential and industrial sources of heat, an absence of vegetation, and air pollution[58] can push temperatures higher than those of the rural surroundings, commonly anywhere in the range of 0.1°C–3°C in global mega-cities.[59] One estimate made on the UHI effect in Colombo, Sri Lanka suggested urbanization may have driven around a 1.6°C increase in land surface temperatures.[60] As well as impacting on human health (see Communities) the temperature peaks that will result from combined UHI and climate change, as well as future urban expansion, are likely to damage the productivity of the service sector economy, both through direct impacts on labor productivity, but also through the additional costs of adaptation.

As of 2017, just under 30% of Sri Lanka's gross electricity generation came from hydropower. Much of the country's water resources are used for hydropower generation and irrigation and the balance is discharged to the sea. Over 60% of the water that is discharged comes from the wet zone and often leads to floods and water-logged lowlands.[61] Research suggests that on average, a one degree increase in ambient temperature can result in a 0.5%–8.5% increase in electricity demand.[62] Notably, this is to support increased demand for business

---

56 Dunne, J. P., Stouffer, R. J., & John, J. G. (2013). Reductions in labor capacity from heat stress under climate warming. Nature Climate Change, 3(6), 563–566. URL: http://www.precaution.org/lib/noaa_reductions_in_labour_capacity_2013.pdf

57 Mani, M., Bandyopadhyay, S., Chonabayashi, S., Markandya, A., Mosier, T. (2018). South Asia's Hotspots: The Impact of Temperature and Precipitation changes on living standards. South Asian Development Matters. World Bank, Washington, DC. URL: https://openknowledge.worldbank.org/bitstream/handle/10986/28723/9781464811555.pdf?sequence=5&isAllowed=y

58 Cao, C., Lee, X., Liu, S., Schultz, N., Xiao, W., Zhang, M., & Zhao, L. (2016). Urban heat islands in China enhanced by haze pollution. Nature Communications, 7, 1–7. URL: https://www.nature.com/articles/ncomms12509

59 Zhou, D., Zhao, S., Liu, S., Zhang, L., & Zhu, C. (2014). Surface urban heat island in China's 32 major cities: Spatial patterns and drivers. Remote Sensing of Environment, 152, 51–61. URL: https://www.researchgate.net/publication/263283084_Surface_urban_heat_island_in_China's_32_major_cities_Spatial_patterns_and_drivers

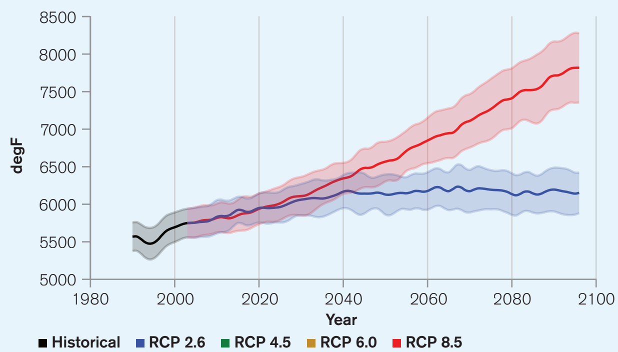
60 Ranagalage, M., Estoque, R. C., & Murayama, Y. (2017). An Urban Heat Island Study of the Colombo Metropolitan Area, Sri Lanka, Based on Landsat Data (1997–2017). ISPRS International Journal of Geo-Information, 6(7). URL: https://www.mdpi.com/2220-9964/6/7/189

61 Ministry of Environment (2012). Sri Lanka's Second National Communication on Climate Change. URL: https://unfccc.int/sites/default/files/resource/lkanc2_0.pdf

62 Santamouris, M., Cartalis, C., Synnefa, A., & Kolokotsa, D. (2015). On the impact of urban heat island and global warming on the power demand and electricity consumption of buildings—A review. Energy and Buildings, 98, 119–124. URL: https://pdfs.semanticscholar.org/17f8/6e9c161542a7a5acd0ad500f5da9f45a2871.pdf

and residential air-cooling systems. The increase in demand associated with rising temperatures under climate change can be captured in the indicator. Cooling Degree Days, representing the total burden of cooling required to maintain temperatures at the optimum level for human comfort. In Sri Lanka the projected increase in cooling requirement is very significant, rising at least 10% by the 2040s under all emissions pathways (**Figure 12**). This increase in demand places strain on energy generation systems which are compounded by the heat stress on the energy generation system itself, commonly due to its own cooling requirements, which can reduce its efficiency.[63]

FIGURE 12. Historic and projected annual cooling degree days in Sri Lanka (cumulative degrees above 65°F) under RCP2.6 (blue) and RCP8.5 (red). The values shown represent the median of 30+ GCM model ensemble with the shaded areas showing the 10–90th percentiles[23]



Tourism

Tourism is a vital component of Sri Lanka's economy. The World Travel and Tourism Council (WTTC) suggest that tourism directly contributed 5% of total employment, and indirectly to 11% of national employment.[64] The large majority of Sri Lanka's tourism economy is located along the coastal zone and is therefore exposed to multiple climate hazards, including sea-level rise and associated enhancement of erosion and storm surge risk, river flooding, extreme rainfall, and extreme heat. Research examining the potential impacts of increased climate variability and intensified extremes of temperature and rain specific to Sri Lanka's tourism economy is lacking.[65]

It is expected that Sri Lanka will have to bear potentially very large adaptation costs to protect its tourism economy. Recent examples of this can be seen in recent activities of the Sri Lanka Tourism Development Authority related to climate change, including large investments in beach nourishment and protection.[66] One study has explored the risks and trade-offs that will be faced over the 21st century as communities and infrastructure are forced to retreat from the present-day coast as sea level rises and storm surge risk increases. An optimal retreat distance of between 37 and 262 m along Sri Lanka's east coast is proposed, a move which will be associated with significant economic costs.[67]

---

[63] ADB (2017). Climate Change Profile of Pakistan. Asian Development Bank. URL: https://www.adb.org/sites/default/files/publication/357876/climate-change-profile-pakistan.pdf

[64] WTTC (2018). Travel and Tourism Economic Impact 2018: Sri Lanka. World Travel and Tourism Council. URL: https://www.wttc.org/economic-impact/country-analysis/country-reports/

[65] Scott, D., Gössling, S., & Hall, C. M. (2012). International tourism and climate change. Wiley Interdisciplinary Reviews: Climate Change, 3(3), 213–232. URL: https://onlinelibrary.wiley.com/doi/epdf/10.1002/wcc.165

[66] Su, Y.-P., & Hall, M. (2015). Climate Change and Tourism in Asia: A Review. In Responding to Climate Change – Tourism Initiatives in Asia and the Pacific (p. Chapter 2). United Nations World Tourism Organization. URL: https://www.academia.edu/7208168/Climate_Change_and_Tourism_in_Asia_A_Review

[67] Dastgheib, A., Jongejan, R., Wickramanayake, M., & Ranasinghe, R. (2018). Regional Scale Risk-Informed Land-Use Planning Using Probabilistic Coastline Recession Modelling and Economical Optimization: East Coast of Sri Lanka. Journal of Marine Science and Engineering, 6(4). URL: https://www.mdpi.com/2077-1312/6/4/120

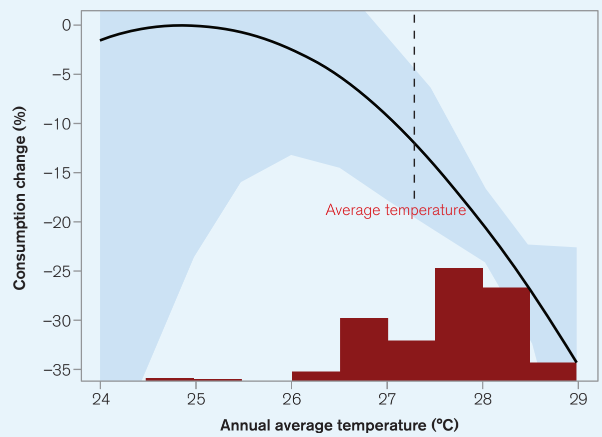
Communities

Poverty and Inequality

Many of the climate changes projected are likely to disproportionately affect the poorest groups in Sri Lanka. For example, heavy manual labor jobs are commonly among the lowest paid whilst also being most at risk of productivity losses due to heat stress.[68] Poorer businesses are least able to afford air conditioning, an increasing need given the projected rise in cooling degree days. Poorer farmers and communities are least able to afford local water storage, irrigation infrastructure, and technologies for adaptation. Sri Lanka was identified as a country with a particularly high vulnerability to food price rises, and as a nation which should expect a particularly large increase in extreme poverty in the event of any climate-driven price rise.[69] These processes are likely to amplify existing societal inequalities and vulnerabilities, for example, between rural and urban areas. As of 2015, access to improved drinking water sources was around 3.5% higher in urban areas compared to rural.[70]

One lens through which to view the impact of changes is through the correlation of consumption patterns with temperature. Work by Mani et al. (2018) describes this relationship, and particularly the way consumption (used as an indicator of living standards) declines beyond a certain threshold temperature.[57] The research suggests that Sri Lanka's average temperature is already higher than the optimal level for maximum consumption (**Figure 13**) and that further increases, manifested by impacts on the productivity of labor and human health, could reduce living standards. Sri Lanka has been identified as a particular hotspot, where declines in living standards due to temperature increases are expected to be some of the most marked in South Asia.[57] Under higher emissions pathways, northern and western regions of Sri Lanka, such as Jaffna district, are projected to see income declines of up to 10% by the 2050s. In these regions, climate changes could be compounding high levels of existing deprivation.

FIGURE 13. The relationship between temperature and consumption in Sri Lanka, shaded areas represent 90% confidence intervals. Black line shows the relationship between temperature and consumption and the optimum temperature (around 25°C) at which no consumption is lost[71]



[68] Kjellstrom, T., Briggs, D., Freyberg, C., Lemke, B., Otto, M., Hyatt, O. (2016). Heat, human performance, and occupational health: A key issue for the assessment of global climate change impacts. Annual Review of Public Health: 37: 97–112. URL: https://www.ncbi.nlm.nih.gov/pubmed/26989826

[69] Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Kane, T., Narloch, U., Rozenberg, J., Treguer, D., and Vogt-Schilb, A. (2016). Shock Waves: Managing the Impacts of Climate Change on Poverty. Climate Change and Development Series. Washington, DC: World Bank. URL: https://openknowledge.worldbank.org/bitstream/handle/10986/22787/9781464806735.pdf?sequence=13&isAllowed=y

[70] WHO/UNICEF (2018). Joint Monitoring Program (JMP) for Water Supply and Sanitation. URL: https://www.unwater.org/publication_categories/whounicef-joint-monitoring-programme-for-water-supply-sanitation-hygiene-jmp/

[71] Mani, M., Bandyopadhyay, S., Chonabayashi, S., Markandya, A., Mosier, T. (2018). South Asia's Hotspots: The Impact of Temperature and Precipitation changes on living standards. South Asian Development Matters. World Bank, Washington, DC. P. 5. URL: https://openknowledge.worldbank.org/bitstream/handle/10986/28723/9781464811555.pdf?sequence=5&isAllowed=y

Human Health

Nutrition

The World Food Program estimates that without adaptation, the risk of hunger and child malnutrition on a global scale could increase by 20%, respectively, by 2050.[72] Work by Springmann et al. (2016) has assessed the potential for excess, climate-related deaths associated with malnutrition.[73] The authors identify two key risk factors that are expected to be the primary drivers: a lack of fruit and vegetables in diets, and health complications caused by increasing prevalence of people underweight. The authors' projections suggest there could be approximately 73 climate-related deaths per million population linked to lack of food availability in Sri Lanka by the 2050s under RCP8.5.

Heat-Related Mortality

Research has placed a threshold of 35°C (wet bulb ambient air temperature) on the human body's ability to regulate temperature, beyond which even a very short period of exposure can present risk of serious ill-health and death.[32] While temperatures significantly lower than the 35°C threshold of 'survivability' can still represent a major threat to human health, climate change could push global temperatures closer to this temperature 'danger zone' both through slow-onset warming and intensified heat waves. Northern Sri Lanka is identified by Im et al. (2017) as facing a potential human health threat from temperatures approaching 35°C.[32] The region's vulnerability is driven by high ambient temperatures, but risks are amplified by the relatively high prevalence of agricultural laborers working outdoors and by low income levels. These risks are significantly mitigated by the pursuing of lower global emissions pathways. Work by Honda et al. (2014), which utilized the A1B emissions scenario from CMIP3 (most comparable to RCP6.0), estimates that without adaptation, annual heat-related deaths in the South Asian region will increase 149% by 2030 and 276% by 2050.[74] The potential reduction in heat-related deaths achievable by pursuing lower emissions pathways is significant, as demonstrated by Mitchell et al. (2018).[75]

Disease

Climate change pressures, such as increased incidence of drought, extreme rainfall, and flood, as well as higher temperatures, represent environmental drivers of vector and water-borne diseases. For example, higher average, maximum and minimum temperatures all correlate with greater dengue incidence.[76] The World Health Organization (WHO) projects an increase in the capacity for dengue fever transmission under all emissions pathways.[77] A similar

---

72 WFP (2015). Two minutes on climate change and hunger: A zero hunger world needs climate resilience. The World Food Program. URL: https://docs.wfp.org/api/documents/WFP-0000009143/download/

73 Springmann, M., Mason-D'Croz, D., Robinson, S., Garnett, T., Godfray, H. C. J., Gollin, D., . . . Scarborough, P. (2016). Global and regional health effects of future food production under climate change: a modelling study. The Lancet: 387: 1937–1946. URL: https://www.sciencedirect.com/science/article/pii/S0140673615011563?via%3Dihub

74 Honda, Y., Kondo, M., McGregor, G., Kim, H., Guo, Y-L, Hijioka, Y., Yoshikawa, M., Oka, K., Takano, S., Hales, S., Sari Kovats, R. (2014). Heat-related mortality risk model for climate change impact projection. Environmental Health and Preventive Medicine 19: 56–63. URL: https://link.springer.com/article/10.1007/s12199-013-0354-6

75 Mitchell, D., Heaviside, C., Schaller, N., Allen, M., Ebi, K. L., Fischer, E. M., . . . Vardoulakis, S. (2018). Extreme heat-related mortality avoided under Paris Agreement goals. Nature Climate Change, 8(7), 551–553. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6181199/

76 Choi, Y., Tang, C. S., McIver, L., Hashizume, M., Chan, V., Abeyasinghe, R. R., . . . Huy, R. (2016). Effects of weather factors on dengue fever incidence and implications for interventions in Cambodia. BMC Public Health, 16(1), 1–7. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4784273/

77 WHO (2015). Climate and Health Country Profiles - Sri Lanka. URL: https://apps.who.int/iris/bitstream/handle/10665/246141/WHO-FWC-PHE-EPE-15.45-eng.pdf?sequence=1

scenario is expected for transmission of malaria, with a potential increase in the at-risk population of approximately 5 million people by the 2060s. Other disease vulnerabilities include increased potential for transmission of water-borne diseases after flood events, exacerbated in urban areas by inadequate drainage and sewerage systems.

Diarrheal disease is a comparatively low health risk to children in Sri Lanka, reflecting the country's good progress tackling issues of clean water access and sanitation. United Nations Children's Fund (UNICEF) estimates that around 50 children under 5 years of age died as a result of diarrheal disease in 2016.[78] This represents around 2% of all under-5 deaths in Sri Lanka. Modelling by WHO estimates the change in the number of diarrheal deaths in under 15-year-olds attributable to climate change under the A1B scenario in the South Asia region. Climate change is projected to increase the number of deaths in the 2030s by 5%–15% and by 10%–20% in the 2050s.[79]

POLICIES AND PROGRAMS

National Adaptation Policies and Strategies

TABLE 8. Key national adaptation policies, strategies, and plans

Policy, Strategy, Plan	Status	Document Access
National Adaptation Plan (NAP) for Climate Change Impacts in Sri Lanka	Enacted	November, 2016
Nationally Determined Contribution	Submitted	November, 2016
National Communications to the UNFCCC	Two submitted	Latest: March, 2012
Technology Needs Assessment (TNA)	Completed	December, 2011
National Policy on Disaster Management	Enacted	December, 2010

Climate Change Priorities of ADB and the WBG

ADB Country Partnership Strategy

ADB's Country Partnership Strategy (CPS) (2018–2022) with Sri Lanka seeks to strengthen the country's environment, climate change, and disaster risk management. In support of these efforts, ADB will expand its assistance in clean energy (wind and solar), natural resource management, expansion of the sewerage network, improve water conservation through leakage reduction, and sustainable transport through railways network improvement. Considerations of environmental, climate, and disaster resilience will be mainstreamed in ADB operations. ADB will support the government's efforts to mitigate greenhouse gas emissions through

[78] UNICEF (2019). Data: Diarrhoeal Disease. URL: https://data.unicef.org/topic/child-health/diarrhoeal-disease/ [accessed 29/01/2019]

[79] WHO (2014). Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. World Health Organization. URL: https://apps.who.int/iris/handle/10665/134014

implementing climate change adaptation technologies and an integrated disaster risk management mechanism. Knowledge support will be provided through key studies for environmental management (conservation, adaptation, and mitigation).

(i) **Improving system efficiencies and water productivity.** This study will investigate inefficiencies in the conveyance and irrigation systems and constraints to improving water productivity, and recommend on-farm and system-wide improvements.

(ii) **Strengthening institutions with integrated water resources management.** This study will recommend programs for modernizing policy and governance frameworks, and institutional strengthening to improve national water resources planning and management, and operation and maintenance procedures.

(iii) **Water productivity assessment for improved irrigation performance.** This study will support irrigation managers to take appropriate measures during crop water stress and water shortages. Satellite remote sensing techniques will be used.

WBG Country Partnership Framework

The WBG has agreed on a Country Partnership Framework (CPF) (2017–2020) with Sri Lanka, in which climate change issues are discussed throughout the agreement, but are particularly addressed under its third pillar: seizing green growth opportunities, improving environmental management, and enhancing adaptation and mitigation potential. This agreement will target the enhanced resilience to climate-related events and disaster risk management through the implementation of a comprehensive, evidence-based, and innovative climate resilience program that addresses the physical and fiscal impacts of climate change and natural disaster, and move toward more integrated water resource management.

CLIMATE RISK COUNTRY PROFILE

SRI LANKA

WORLD BANK GROUP

ADB ASIAN DEVELOPMENT BANK

Annex IV

NATIONAL ADAPTATION PLAN FOR CLIMATE CHANGE IMPACTS IN SRI LANKA

2016 - 2025

Ministry of Mahaweli Development and Environment

Sri Lanka

National Adaptation Plan for Climate Change Impacts in Sri Lanka

2016 - 2025

Climate Change Secretariat
Ministry of Mahaweli Development and Environment
2016

National Adaptation Plan for Climate Change Impacts in Sri Lanka: 2016 - 2025

Climate Change Secretariat
Ministry of Mahaweli Development and Environment
2016

National Adaptation Plan for Climate Change Impacts in Sri Lanka

Published by	**Climate Change Secretariat,** **Ministry of Mahaweli Development and Environment**
Year of Publication	**2016**

ISBN	**978-955-0033-98-0**
Consultation	**Institute of Policy Studies of Sri Lanka**
Coordination	**Climate Change Secretariat** **Ministry of Mahaweli Development and Environment** **No: 980/4A, Wickramasinghe Place,** **Ethul Kotte, Sri Lanka.** **Tel: +94 (0) 112883481 / +94 (0) 112883368** **Fax: +94 (0) 112076782** **E-mail: climatesec@gmail.com** **Web: www.climatechange.lk**
Cover page design	**Mr. Dasun Hewapathirana** **Development Officer, Climate Change Secretariat** **Ministry of Mahaweli Development and Environment**
Layout and Print	**J & D Publishing House**

The Message of the National Focal Point to UNFCCC

As a small island and a developing nation, Sri Lanka is highly vulnerable to the adverse effects of climate change. Consequences of climate change such as temperature rise, rainfall variability and sea level rise are critically affecting almost all economic sectors of the country. Occurrences of natural disasters due to extreme weather conditions such as prolonged droughts, flash floods and landslides deprive lives and livelihoods of people.

Ratification of the Paris Agreement further to the United Nations Framework Convention on Climate Change (UNFCCC) is one more step forward for committing Sri Lanka to address climate change and related issues. Although mitigation of greenhouse gases is the highlighted portion of the Paris Agreement, we still believe that building resilience of vulnerable communities and ecosystems over climate change effects within a broader framework of sustainable development should be our priority as a developing country.

Recognizing this responsibility, the Government of Sri Lanka has launched a national initiative for facing the threat of climate change. I am happy that the Ministry of Mahaweli Development and Environment has played the leadership role in this effort by developing the National Climate Change Adaptation Strategy for Sri Lanka in 2010 and developing the National Climate Change Policy adopted in 2012. The National Adaptation Plan (NAP) presented in this document, which is the next logical step of this initiative, is a country-driven, gender-sensitive and a fully transparent approach to deal with climate change impacts on Sri Lanka.

The National Adaptation Plan of Sri Lanka has identified agriculture, fisheries, water, human health, coastal and marine, ecosystems and biodiversity, infrastructure and human settlements as the most vulnerable sectors to the adverse effects of climate change. This Plan provides the opportunity for all the stakeholders for developing policies, strengthening cooperation, institutional setup, resources mobilization, technology development and transfer, awareness and capacity building to increase resilience of vulnerable communities, areas and sectors in the country.

In order to implement the NAP of Sri Lanka, we expect the external support for further strengthening the national adaptation planning process in the country, and technical and financial assistance to make these actions realistic at the ground level. It is my pleasure to take this opportunity to deliver a bouquet of appreciation for the partners and stakeholders who engage in developing the NAP of Sri Lanka.

This is one of our commitments to achieve the ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC), its COP decisions and the Paris Agreement.

Udaya R. Senevirathne
Secretary
Ministry of Mahaweli Development and Environment, Sri Lanka

Contributors

Advisors

Mr. Udaya R. Seneviratne	Secretary, Ministry of Mahaweli Development and Environment
Mr. Gamini Gamage	Additional Secretary (Environment and Policy) Ministry of Mahaweli Development and Environment
Dr. R.D.S. Jayathunga	Director, Climate Change Secretariat Ministry of Mahaweli Development and Environment

Team of Consultants

Dr. Athula Senaratne	Research Fellow & Head/ Environmental Economics Policy Unit, Institute of Policy Studies of Sri Lanka
Mr. Chatura Rodrigo	Research Economist, Institute of Policy Studies of Sri Lanka
Ms. Kanchana Wickramasinghe	Research Economist, Institute of Policy Studies of Sri Lanka

Coordination Team

Ms. H.N.K.T. Dulani	Assistant Director, Climate Change Secretariat Ministry of Mahaweli Development and Environment
Mr. Ranjith Rajapakse	Environmental Management Officer, Climate Change Secretariat Ministry of Mahaweli Development and Environment
Ms. Shyamali Priyanthie	Environmental Management Officer, Climate Change Secretariat Ministry of Mahaweli Development and Environment
Mr. Ranjith Wimalasiri	Environmental Management Officer Ministry of Mahaweli Development and Environment
Mr. Dasun Hewapathirana	Development Officer, Climate Change Secretariat Ministry of Mahaweli Development and Environment

Expert Contribution

National Experts Committee on Climate Change Adaptation (NECCCA)
Officials of Ministries, Departments and Agencies of adaptation sectors
Private sector, Civil Societies and Academia

Executive Summary

Climate change impacts are looming over every conceivable level; global, regional, national and local that calls for multi-level action. Sri Lanka, a tropical nation, is highly vulnerable to adverse impacts of climate change. National level actions have to play a critical role while international cooperation is also important. Recognizing this responsibility, the Government of Sri Lanka (GOSL) has launched a national initiative to face the impacts of climate change. The Climate Change Secretariat of the Ministry of Mahaweli Development and Environment plays the leadership role in this activity which is the National Focal Point for the United Nations Framework Convention on Climate Change (UNFCCC), spearheads the process. Among the key national initiatives, the *National Climate Change Adaptation Strategy for Sri Lanka 2011-2016* prepared in 2010 and the *National Climate Change Policy* (NCCP) adopted in 2012 are the two major achievements. The *National Adaptation Plan* for *Climate Change Impacts in Sri Lanka* (NAP) is the next logical step of the National initiatives for meeting the adverse effects of climate change adaptation.

The *National Adaptation Plan* for *Climate Change Impacts in Sri Lanka* (NAP) was prepared in line with the broad set of guidelines set forth by the UNFCCC for the development of national adaptation plans. The NAP process of UNFCCC is a generalized process consisting of four stages that could be customized according to specific situations in respective countries. The NAP process in Sri Lanka started from the stage of preparatory elements, which is the real planning stage of the process, and a country-specific NAP methodology was developed and adopted based on the broader guidelines of the UNFCCC.

The importance of adaptation as a major strategy for facing the threat of climate change has been recognized by all parties to Paris Agreement and called for national actions for adaptation under Intended Nationally Determined Contributions (INDCs). The necessity of adaptive strategies has also been highlighted by number of Sustainable Development Goals (SDGs) adopted by the United Nations in 2015.

The NAP covers adaptation needs at two levels, namely; adaptation needs of key vulnerable sectors and cross-cutting national needs of adaptation. Nine vulnerable sectors were identified in the consultative process, i.e. food security, water, coastal sector, health, human settlements, bio-diversity, tourism and recreation, export development and industry- energy-transportation. Broader stakeholder consultation adopted in the preparation of the NAP has helped to identify adaptation needs of each vulnerable sector based on logical criteria involving projections, vulnerabilities, impacts and socio-economic outcomes. The NAP identifies adaptation options that can fulfill these needs and actions necessary to achieve these adaptation options with responsible agencies and key performance indicators. They together constitute the sectoral action plans for each vulnerable sector. The NAP also includes interventions necessary to fulfill cross-cutting national needs of adaptation identified on the basis of analyzing common sectoral needs and opinions of key stakeholders. The plan also proposes an institutional and coordination mechanism along with implementation and resource mobilization strategies for the successful implementation of the NAP based on a realistic timeframe.

Table of Contents

List of Tables

List of Figures

List of Boxes

List of Abbreviations and Acronyms

AchFoU	Architecture Faculties of Universities
AFoU	Agriculture Faculties of Universities
AR5	The Fifth Assessment Report
CAC	Climate Adaptation Cells
CARP	Sri Lanka Council for Agricultural Research Policy
CC&CRMD	Coast Conservation and Coastal Resources Management Department
CCS	Climate Change Secretariat
CDA	Coconut Development Authority
CEA	Central Environmental Authority
CEB	Ceylon Electricity Board
CHPB	Centre for Housing Planning and Building
CIP	Climate Information Products
CRI	Coconut Research Institute
CSO	Civil Society Organization
DAD	Department of Agrarian Development
DAPH	Department of Animal Production and Health
DCD	Department of Cooperatives Development
DFAR	Department of Fisheries and Aquatic Resources
DFC	Food Commissioner's Department
DM	Department of Meteorology
DMC	Disaster Management Centre
DNBG	Department of National Botanical Gardens
DNZG	Department of National Zoological Gardens
DOA	Department of Agriculture
DOArch	Department of Archeology
DOI	Department of irrigation
DWLC	Department of Wild Life Conservation
EFoU	Engineering Faculties of Universities
FD	Forest Department
FIM	First Inter-Monsoon
GOSL	The Government of Sri Lanka
ICTAD	The Institute for Construction Training and Development
IDB	Industrial Development Board
IPCC	Inter-governmental Panel for Climate Change
ITI	Industrial Technology Institute

IUCN	International Union for Conservation of Nature
IWMI	International Water Management Institute
Las	Local Authorities
LEG	Least Developed Countries Expert Group
MASL	Mahaweli Authority of Sri Lanka
ME	Ministry of Environment
MENR	Ministry of Environment and Natural Resources
MEPA	Marine Environmental Protection Authority
MMDE	Ministry of Mahaweli Development and Environment
MODM	Ministry of Disaster Management
MOE	Ministry of Education
MOH	Ministry of Health
MOPI	Ministry of Plantation Industries
MOT	Ministry of Transport
MRI	Medical Research Institute
MSL	Mean Sea Level
NABRO	National Building Research Organization
NAF	National Adaptation Fund
NAP	National Adaptation Plan
NAQDA	National Aquatic Development Authority
NARA	National Aquatic Resources Research and Development Agency
NBRO	National Building Research Organization
NCCAS	National Climate Change Adaptation Strategy
NCCP	National Climate Change Policy
NCPC	National Cleaner Production Centre
NEM	Northeast monsoon
NERD	National Engineering Research and Development Center
NGOs	Non-Governmental Organization
NIPM	National Institute of Plantation Management
NLDB	National Livestock Development Board
NPPD	National Physical Planning Development
NRC	National Research Council of Sri Lanka
NSF	National Science Foundation
NWG	National Working Group
NWSDB	National Water Supply and Drainage Board
OFC	Other Food Crops
PCs	Provincial Councils
PMB	Paddy Marketing Board
RDA	Road Development Authority

RDD	Department of Rubber Development
RPTAs	Road Passenger Transport Authority
RRI	Rubber Research Institute
SD	Survey Department
SEA	Sri Lanka Sustainable Energy Authority
SFoU	Science Faculties of Universities
SIM	Second Inter-Monsoon
SLCC	Sri Lanka Cashew Corporation
SLR	Sri Lanka Railways
SLTDA	Sri Lanka Tourism Development Authority
SLTPB	Sri Lanka Tourism Promotion Bureau
SRI	Sugarcane Research Institute
SVP	Sector Vulnerability Profile
SWM	Southwest monsoon
TBSL	Tourism Board of Sri Lanka
TFoU	Tourism Faculties of Universities
THASL	The Hotel Association of Sri Lanka
TNA	Technology Needs Assessment
TRI	Tea Research Institute
UDA	Urban Development Authority
UNCCS	United Nations Climate Change Secretariat
UNFCCC	United Nations Framework Convention for Climate Change
VRI	The Veterinary Research Institute
WMO	World Meteorological Organization
WRB	Water Resources Board

1. Introduction

The Fifth Assessment Report (AR5) of Inter-governmental Panel on Climate Change (IPCC) emphasizes that the current as well as future generations will have to face multiple impacts of climate change with far reaching consequences. According to the World Meteorological Organization (WMO), 13 out of the 14 hottest years were reported since year 2000 and each successive decade since 1980 has been warmer than the previous one, having 2001-2010 recorded as the warmest decade ever (WMO, 2014). Scientific studies have shown that mean sea-level (MSL) has increased by 0.19 meters during the last century and it is projected to rise even faster during this century (IPCC, 2014). The thermal expansion of oceans and melting of glaciers due to global warming are mainly responsible for this. Reports also suggest that seasonal melting of major ice sheets and glaciers have accelerated during the recent past and significant areas of snow cover have permanently disappeared (IPCC, 2014). These changes in the global climate could lead to create impacts with negative physical and socio-economic outcomes around the world.

Sri Lanka, a tropical nation, is highly vulnerable to impacts of climate change. As a small island in the Indian Ocean, the coastal region of Sri Lanka is susceptible to changes in sea level. The 2004 tsunami has indicated that low-lying plains in the coastal zone will be vulnerable to any future rise in sea level. Important sectors of the economy such as tourism and fisheries could be affected due to impacts of sea level rise (Ahmed and Supachalasai, 2014; ME, 2010 a; Senaratne et al., 2009). A significant population of the country is dependent on livelihoods connected to agriculture. Studies show that food security of the nation can be adversely affected due to impacts of climate change (De Costa, 2008; De Silva, 2008 and 2013; Marambe et al., 2013, 2015a; Punyawardena, 2007). Besides, a substantial share of Sri Lanka's foreign income is earned through export crops which are highly sensitive to fluctuations of weather (Nissanka et al., 2013; Ranasinghe, 2013; Wijeratne et al., 2007). Emerging evidence from various sources suggest that climate change could alter natural systems connected to water cycle, eco systems and bio-diversity of the country (Eriyagama et al., 2010; Marambe et al., 2012; ME, 2011; Weerahewa et al., 2012). This could lead to the decline of various ecosystem services that are indispensable for the welfare of human population. Impacts of climate change appear to have significant repercussions on health of the citizens and human settlements of the country too (ME, 2010 b and c). Overall, the impacts of climate change are widespread and they are likely to create negative socio-economic outcomes on many sectors in Sri Lanka.

Adaptation is the key strategy available for facing the impacts of climate change. Climate adaptation is widely defined as actions taken to moderate, cope or take advantage of experienced or anticipated changes in climate (IPCC, 2007). However, scholars who look from the social perspective suggest that the essence of the concept of adaptation is adjustment of behaviour (Adger et al., 2009; Smit et al., 2000; Smith et al., 1996; Stakhiv, 1993). Hence, more precisely, climate adaptation can be defined as 'adjustments in behaviour of natural and social systems and their members in response to actual or expected variability or change in climate in order to moderate and cope with harmful impacts or to take advantage of opportunities.

2015 is a landmark year for global efforts on climate change and sustainable development. In this year, global community was successful in breaking the deadlock in international climate negotiations by reaching a historical agreement in Paris. Simultaneously, world leaders adopted Sustainable Development Goals (SDGs) in the United Nations General Assembly. As a responsible member of the global community, Sri Lanka is expected to make contributions towards both overcoming the challenges of climate change as well as achieving SDGs. The Paris Climate Agreement is based on Intended Nationally Determined Contributions (INDCs) for mitigation of and adaptation to climate change. Accordingly, Sri Lanka signed the Paris Climate Agreement in April 2016 and submitted Sri Lanka's INDCs covering national commitments to both mitigation and adaptation. The adaptation commitments in INDCs are largely based on the adaptation options and actions identified in the NAP process and hence this plan is fully consistent with Sri Lanka's commitments towards global efforts on adaptation. In the final count, adaptation is all about achieving the long-term goals of sustainable development in the face of rising risk of climate change. Hence, the NAP should invariably contribute to achieve SDGs. The SDGs have 17 goals and 169 targets of which Goal Number 13 is fully dedicated to climate change with 9 targets associated with it. In addition, number of other goals covers areas relevant to climate change adaptation with relevant targets attached to them. Sri Lanka's NAP is essentially contributing to number of SDGs and they are especially highlighted in the plan.

Being a phenomenon with impacts looming over every conceivable level, i.e. global, regional, national and local, climate change calls for multi-level actions for adaptation. The national level actions have to play a critical role while international cooperation is also important. At the national level, the government has the responsibility of coordinating adaptation decisions taken at international and provincial levels as well.

Recognizing this responsibility, the Government of Sri Lanka (GOSL) has launched a national initiative to face the threat of climate change (Jayathunga and Kumari, 2013; Marambe et al., 2015b). The Climate Change Secretariat of the Ministry of Mahaweli Development and Environment (MMDE) plays the leadership role here.

Sri Lanka's capacity for successful adaptation to climate change impacts depends on two major factors—vulnerability and adaptive capacity of its people. Sector vulnerability profiles prepared for agriculture, health, water, biodiversity and human settlements have identified many geographical locations and economic sectors that are vulnerable to impacts of climate change

(ME, 2010 a, b &c). Around 28 per cent of the country's population depends on livelihoods related to agriculture, which are highly dependent on climatic conditions. Impacts on agriculture will place not only the livelihoods of farmers, but the food security of the entire population under risk. Poverty is also a major vulnerability-enhancing factor. Even though Sri Lanka has been successful in reducing the poverty head count ratio to a single digit, studies on multi-dimensional poverty indicate that people who are marginally over the poverty line could fall below the line easily due to various livelihood shocks. Hence, climate change impacts have the potential to reverse the country's achievements in poverty alleviation unless countered through appropriate measures of adaptation.

Adaptive capacity implies the ability of people and socio-ecological systems to respond to the impacts of climate change with minimum negative outcomes. Adaptive capacity is determined by several factors that include livelihood assets, knowledge and skills, technology, institutions and information. Unlike in the case of vulnerability, assessments of adaptive capacity are rare in Sri Lanka. However, it is not hard to identify that currently there are many gaps in institutions, technology, knowledge and information concerning impacts of climate change concerned. Hence, successful adaptation requires assessing of the risk and vulnerability, accessing appropriate technologies and sound science, improved institutional mechanisms, multilateral corporations while enhancing the adaptive capacity of people.

1.1.NAP Process in Sri Lanka

The NAP was prepared in line with the broad set of guidelines set forth by UNFCCC's Least Developed Countries Expert Group (LEG) for development of national adaptation plans (NAPs) (LEG, 2012; UNFCCC, 2012). The UNFCCC guidelines identify preparing the NAPs as a process to develop the capacity and knowledge of all decision-makers at national, sub-national (e.g. sectoral, provincial) and supra-national levels. The NAP process of the UNFCCC is a generalized process consisting of four stages that could be customized according to specific situations in respective countries (Box 1). The four stages are: laying the groundwork and identifying gaps; making preparatory elements; implementation strategies, and; reporting, monitoring and reviewing. Of them, the third and fourth are post-plan stages. It is useful to review Sri Lanka's situation with respect to this four stage process.

Initiating and launching the NAP process: Sri Lanka has already started the NAP process and reached two important milestones, namely: the *National Climate Change Policy* (NCCP) and the *National Climate Change Adaptation Strategy for Sri Lanka* (NCCAS)*: 2011 to 2016* (NCCAS 2011-16)*.* These important policy documents elaborate the national vision and strategic priorities with regard to facing the threat of climate change. They also provide a source of legitimacy and authority required for the NAP. In addition, CCS has established its position as the key national agency with specialized mandate for addressing national issues on climate change. These factors can be considered as positive features which strengthen the process for developing, and implementing the NAP in Sri Lanka

Box 1: UNFCCC's Generalized Process for the Preparation of NAPs

UNFCCC identified a generalized process consisting of four stages that could be customized according to specific situations in respective countries. The four stages are: laying the groundwork and identifying gaps; making preparatory elements; implementation strategies, and; reporting, monitoring and reviewing.

Laying the groundwork: This is a pre-planning stage of the NAP process. It covers three major areas: initiating and launching the NAP process; stocktaking and synthesizing available information; identifying vulnerabilities and, analysis of major gaps and potential barriers.

Making preparatory elements: This is the real planning stage of the NAP process. UNFCCC has not identified a specific methodological procedure for the preparation of the Plan but only an overall framework (Figure 1). Planners have to identify the suitable methodological framework for respective countries considering the ground realities in the relevant countries. However, UNFCCC emphasizes the necessity of extensive consultation of relevant stakeholders in the planning stage.

Implementation strategy: The third stage of the NAP process is the implementation stage. This is a post-planning stage that deals with implementing selected interventions in the action plan. However, essential aspects of implementation strategy should be laid down in the Plan itself with the necessary flexibility to make adjustments based on changes in conditions that may come in the future.

Reporting monitoring and reviewing: The final stage of the NAP process is reporting, monitoring and reviewing. It deals with monitoring the implementation of the Plan. This is also a post-planning stage. However, like implementation strategies, there should be built-in mechanisms for reporting, monitoring and reviewing progress of the plan. These mechanisms should help review the progress and iteratively update the plan according to the changing conditions.

Stocktaking, synthesizing information and identifying vulnerabilities: The Ministry of Environment, with the initiatives taken by the CCS, has already published two *National Communications of Climate Change* in 2001 and 2011 that reviewed the existing information. In addition, Sector Vulnerability Profiles (SVPs) have been developed for 5 sectors. The Ministry has also completed the Technology Needs Assessment (TNA) for adaptation and mitigation which identified priority technologies for five adaptation sectors and three mitigation sectors. Several national level conferences organized by various agencies have helped to exchange findings of research conducted by institutions and individual researchers. These developments have established a solid foundation for the NAP process.

Major gaps and barriers: Despite positive factors, however, there are also significant gaps in certain areas. Review of existing literature helped to identify a few major gaps that need to be addressed for successful adaptation in Sri Lanka. They are: information gaps, technological gaps, policy and governance gaps, institutional and coordination gaps and resource mobilization gaps.

Information gaps: Major improvements in generation of climate information products (CIPs) are necessary to provide effective guidance to adaptive actions of different stakeholders.

Technological gaps: Despite that the TNA has been conducted for five important sectors of adaptation, technological gaps in many areas remain largely unexplored.

Policy and governance gaps: Efforts initiated by the MMDE and CCS have helped to fulfill some policy gaps at the national level. The NCCP has established the national vision whereas the NCCAS: 2011-2016 identified strategic priorities. However, climate change is a complex problem that cannot be governed through efforts of a single ministry or a line agency. Hence, there are policy and governance issues that need to be addressed through the NAP process.

Institutional and coordination gaps: Currently, many activities pertaining to adaptation are undertaken in an ad-hoc manner without proper coordination. This cannot be considered a favorable situation and therefore an appropriate institutional mechanism for coordination of different actors is necessary.

Resource mobilization gaps: The government is burdened with numerous fiscal and monetary difficulties to find extra resources for climate adaptation interventions. Therefore, conventional channels of public finance cannot be relied upon to meet all resource needs of adaptation and innovative ways of resource mobilization should be identified.

These gaps act as barriers to successful adaptation thereby leading to reduce the adaptive capacity and increase the vulnerability of individual citizens as well as the nation as a whole.

The major aim of the NAP is overcoming these gaps so that the adaptive capacity of all stakeholders will be enhanced while the vulnerability will be reduced.

Given the situation that many groundwork requirements have already been fulfilled and the NAP process in Sri Lanka was started from the second stage—i.e. by making preparatory elements. This can be considered as the real planning stage of the NAP for Sri Lanka. Essential preparatory elements of the NAP process include: analysing current climate and future climate scenarios; assessing vulnerabilities; identifying, reviewing and appraising adaptation options and, compiling and communicating the NAP (Figure 1).

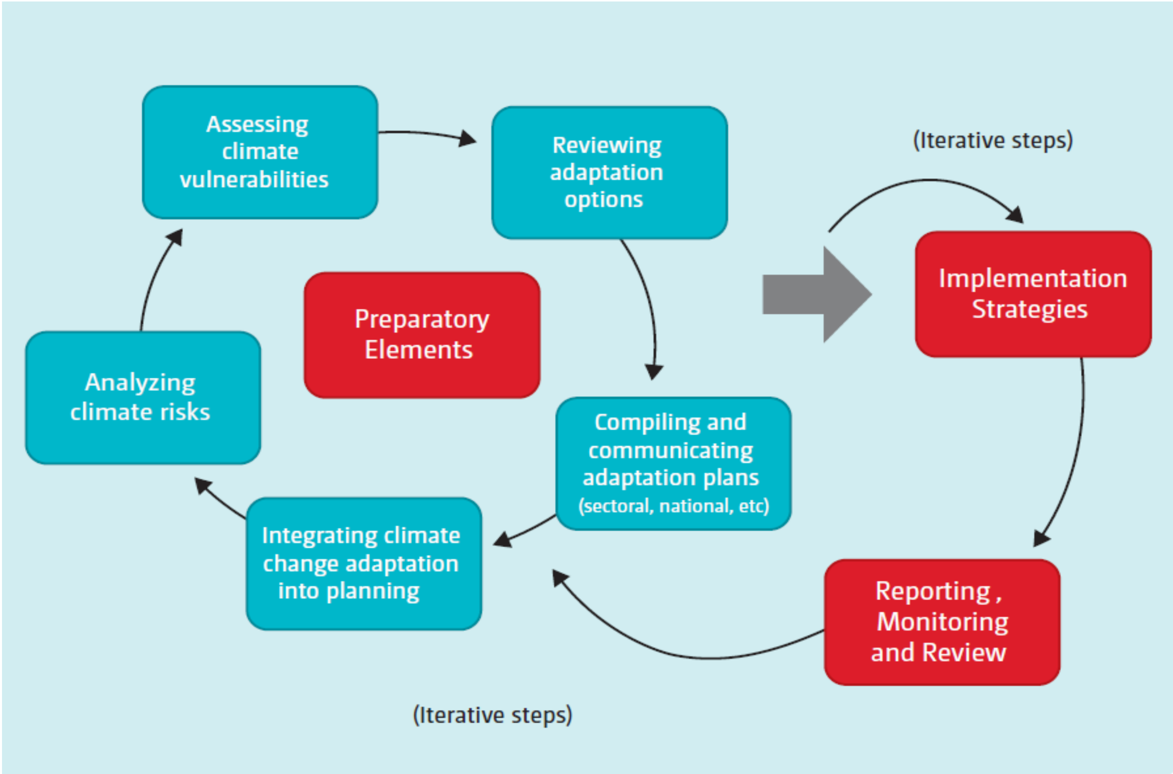


Figure 1: The NAP Process

The UNFCCC guidelines do not offer a detailed planning methodology other than the broad framework shown in Figure 1. It is understood that each country faces different circumstances and a rigid prescriptive methodology would not generate desired results. Instead it remains open for country-driven customized methodologies for the preparation of the NAP. The NAP methodology of Sri Lanka was developed according to these broad guidelines of the UNFCCC and is discussed in Chapter 5 of this Plan.

1.2.Organization of Chapters

Chapter 2 presents an overview of climate change in Sri Lanka. It discusses the average pattern of climate in Sri Lanka together with observed changes in the recent past and projected changes for the future. Chapter 3 describes the scope of the plan together with key stakeholders and the plan’s connectivity to other relevant national policies and plans. Planning concepts and approaches that guided the plan are presented in Chapter 4. The detailed methodology of the plan is described in Chapter 5. The methodology of the plan has a logical structure that begins from the projections on changes in key climatic parameters. Physical effects of projected changes give rise to physical hazards and vulnerabilities on different sectors. The impacts of these hazards and vulnerabilities determine the adaptation needs of respective sectors and feasible adaptation options to cope with impacts that provided the basis of the action plan. This logical structure of the plan is explained in Chapter 6 before the presentation of The Plan in Chapter 7. Chapter 7 presents the plan in detail with summary of priority actions, followed by sector specific actions plans for 9 different sectors, and the plan for cross cutting adaptation needs. Chapter 8 presents the institutional and coordination mechanism while the implementation strategy and the resource mobilization mechanism of the plan are presented in Chapters 9 and 10 respectively.

2. Climate Change in Sri Lanka: An Overview

Successful adaptation against climate change is necessarily an information-driven process. Therefore, the logical starting point of preparing the NAP is reviewing information on the existing situation of climate change in Sri Lanka. This section provides a brief overview of the climate in Sri Lanka, major changes that have been observed in the system and changes projected to take place in future.

2.1. Climate in Sri Lanka

The review of general pattern of climate described in this section is based on Basnayake (2007), Chandrapala (2007 a) and Abhayasinghe (2007). Being a small tropical island, there is no significant annual variation in temperature in Sri Lanka due to latitude. However, significant regional variation in temperature could be observed due to altitude. In lowland areas, average annual temperature usually varies around 26.5 – 28.5 °C and it falls quickly as altitude increases (e.g. Nuwara Eliya – 15.9 °C at 1800 meters above mean sea level).

In the absence of high seasonal variation in temperature, the average pattern of climate in a given local area is determined mainly by the variations in precipitation. Sri Lanka's mean annual rainfall is around 1850 mm (ranging from 900 mm to 5000 mm). There are three major sources of rainfall in the country, namely; monsoonal, convectional and depressional. Based on the variation in precipitation, Sri Lanka's climate is generally divided into four seasons:

1. First inter-monsoon season (FIM): March –April (268 mm, 14%)
2. Southwest monsoon season (SWM): May –September (556 mm, 30%)
3. Second inter-monsoon season (SIM): October-November (558 mm, 30%)
4. Northeast monsoon season (NEM): December- February (479 mm, 26%)

The first inter-monsoon (FIM) rains are usually experienced around March-April period. During the FIM, southwestern quarter and certain parts of central highlands receive over 250 mm rainfall, with some localized areas on the Southwestern slopes experiencing rainfall in excess of 700 mm. Most other parts get rainfall around 100-250 mm. Hazardous lightning associated with thunderstorms is a frequent incident and sometimes intensive rainfall may give rise to flash floods.

The country experiences the Southwestern monsoon (SWM) around May-September. During the SWM season, mid-elevation western slopes of central highlands receive over 3000 mm rainfall and southwestern coastal belt around 1000-1600 mm. Higher elevations in central highlands get rainfall around 800 mm. Long lasting monsoon rains may result in floods in low-lying areas and landslides in hilly areas. Rains can be experienced at any time during the day and night.

Box 2: Observed Changes of Climate in Sri Lanka - Some Scientific Evidence

Temperature: Analysis of past data suggests that atmospheric temperature is gradually rising almost everywhere in the country (Chandrapala, 2007a; De Costa, 2008; Eriyagama et al., 2010; Nissanka et al., 2011; Sathischandra et al., 2014). Varied rates of increase in temperature have been reported from different locations and in recent years, the warming trend has become faster (Basnayake, 2007; Chandrapala, 2007a; De Costa, 2008; Sathischandra et al., 2014). Annual mean air temperature anomalies have shown significant increasing trends in all stations during the recent decades (Basnayake, 2007). It has been reported that mean daytime maximum and mean night time minimum air temperatures also have increased (Basnayake, 2007; Zubair et al., 2005). Data indicates that increase in night time minimum air temperature contributes more to average increase in annual temperature than day time maximum air temperature (Basnayake, 2007).

Precipitation: Unlike in the case of temperature, no clear pattern or trend has been observed in precipitation. Some researchers, comparing the mean annual precipitation of recent and earlier periods, suggest that average rainfall is showing a decreasing trend (Basnayake, 2007; Chandrapala, 2007b; De Costa 2008; Jayatillake et al., 2005). However, there is no consensus on this fact among researchers and opposing trends can be observed in different locations. Punyawardena et al. (2013a) observed that heavy rainfall events have become more frequent in central highlands during the recent period. However, many researchers seem to agree that the variability of rainfall has increased over time, especially in *Yala* season (Chandrapala 2007b; Eriyagama et al. 2010; Punyawardena et al., 2013b). Moreover, the number of consecutive dry days has increased and the consecutive wet periods have decreased (Premalal, 2009; Ratnayake and Herath, 2005). Studies also indicate that spatial distribution of rainfall appears to be changing although a distinct pattern cannot be recognized yet (Basnayake, 2007; Marambe et al., 2013; Nissanka et al., 2011; Sathischandra et al., 2014). Some studies suggest changes in distribution can even lead to shifting of agro-ecological boundaries (Eriyagama et al., 2010; Mutuwatte and Liyanage, 2013).

Extreme events: The intensity and the frequency of the extreme events such as floods and droughts have increased during recent times (Imbulana et al., 2006; Ratnayake and Herath 2005; Premalal and Punyawardena, 2013; Punyawadena and Premalal, 2013). Areas of high rainfall intensities and the locations of landslides show a strong correlation (Ratnayake and Herath, 2005).

Sea level rise: Sea level rise of 1-3 mm/year is observed in the Asian region and is marginally higher than the global averages (Cruz et al., 2007). An accelerated level of sea level rise has been observed during the period of 1993-2001 (3.1 mm/year) for the Asian region. However, specific levels of sea level rise in areas around Sri Lanka are yet to be assessed.

Second inter-monsoon season (SIM) brings rainfall around October-November period. Unlike FIM, the influence of depressions is common during SIM, the whole country experiencing strong winds with widespread rains, sometimes leading to floods and landslides. It is the season with most evenly distributed rainfall in Sri Lanka. Many areas receive over 400 mm. Slopes in southwestern quarter receive 750-1200 mm.

Usual period of northeast monsoon season (NEM) is December-February. During this season moist wind blowing from northeast Asian landmass produces seasonal rainfall in the northern, north central and eastern parts of the country. Highest rainfall figures are recorded in north-eastern slopes of the hill country and eastern slopes of the Knuckles/Rangala range.

This general pattern of annual rainfall results in an overall mean annual rainfall of around 1850 mm that range from 900 mm to 5000 mm. Southwestern quarter of the country, especially western slopes of central highlands receive the highest rainfall (e.g. Yatiyantota, Ginigathhena, Watawala > 5000 mm). On the other hand, southeastern (Yala, Palatupana < 1000 mm) and northwestern (Mannar < 1000 mm) coastal areas receive the lowest amount of rainfall.

Sri Lanka has traditionally been generalized into three climatic zones, namely, 'wet zone' in the Southwestern region including central hill country, 'dry zone' covering predominantly the Northern and Eastern parts of the country, and 'Intermediate Zone', skirting the central hills except in the South and the West. In differentiating these three climatic zones, annual rainfall, contribution of southwest monsoon rains, soil type, land use, and vegetation have been widely used (Punyawardena, 2007). The Wet Zone receives a relatively high mean annual rainfall over 2,500 mm without pronounced dry periods. The Dry Zone receives a mean annual rainfall of less than 1,750 mm with a distinct dry season from May to September. The Intermediate Zone receives a mean annual rainfall between 1,750 and 2,500 mm with a short and less prominent dry season. Sri Lanka has been further divided into 46 agroecological regions (Punyawardena, 2007) that take into account the monthly rainfall amount (at 75 % probability) and distribution in addition to the parameters considered for identifying climate zones. Figure 2 presents the map of agro-ecological zones in Sri Lanka.

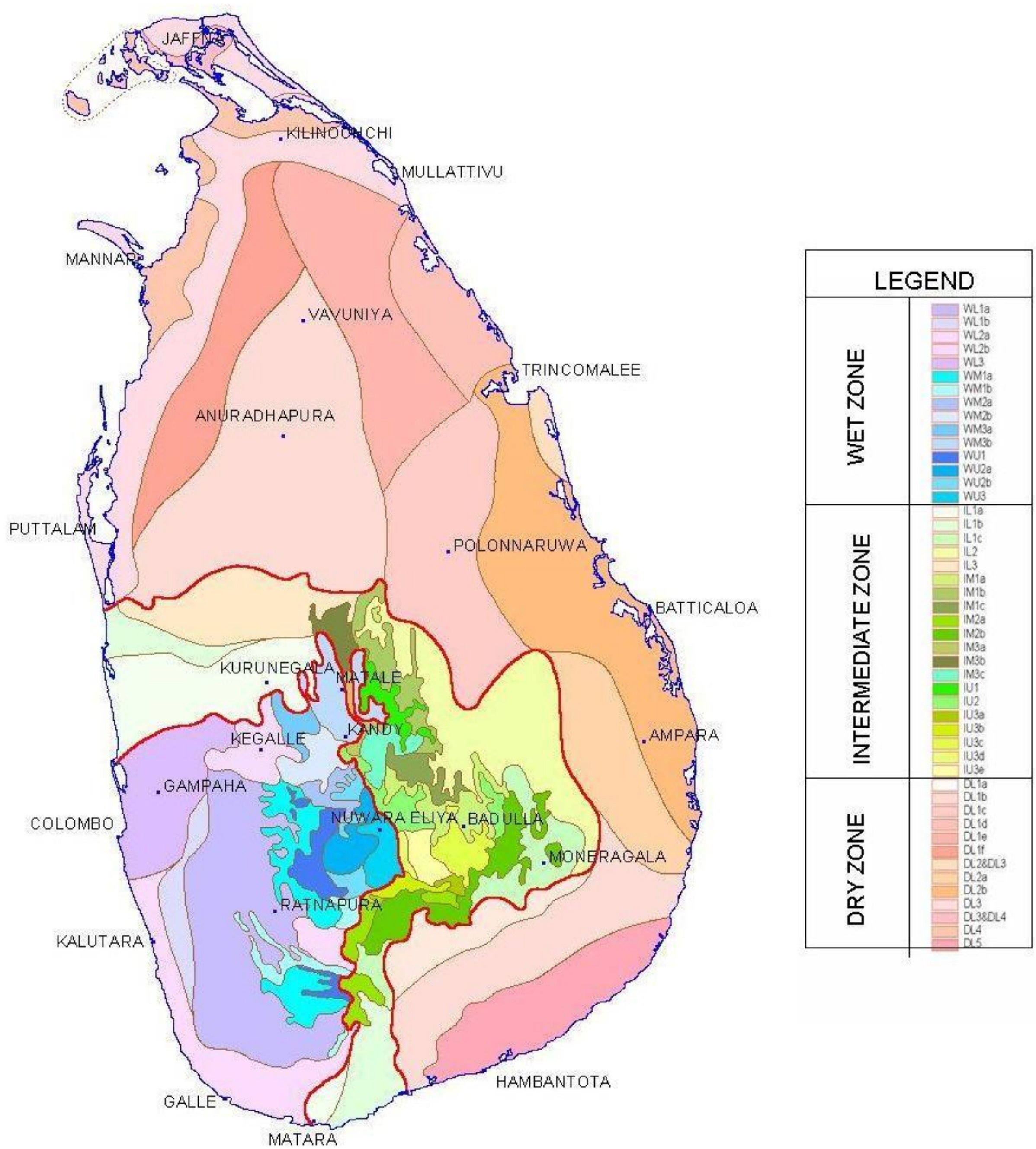


Figure 2: Agro-ecological regions of Sri Lanka

Source: Natural Resources Management Centre, Department of Agriculture (2003).

2.2. Observed and Projected Changes in Climate in Sri Lanka: An Overview

Recent studies on local, regional and global climate suggest that this general pattern of climate is undergoing changes. There are two major sources of information.

- *Observed changes of climate*: These are based on statistical analysis of historically recorded meteorological data over several years across a number of locations in the country
- *Projected changes on climate*: This refers to projections based on global, regional and downscaled climate models for future time periods

Academics and researchers have conducted a number of studies on trends that can be observed from analysis of past meteorological data and they indicate that Sri Lanka's climate is changing gradually. Areas that attracted researchers' attention most were trends in temperature, changes in precipitation patterns and observations on extreme events. Evidence suggests that atmospheric temperature is gradually rising almost everywhere in the country. A major feature of rainfall in Sri Lanka is the high year-to-year variability. However, no distinct pattern of change has been observed. Variation of rainfall is much smaller in lowlands than highlands. A summary of findings from analysis of past data is given in Box 2.

Projected changes are likely future trends of key meteorological parameters according to projections of climate models, which are complex mathematical models. Global climate models provide limited information on a smaller country like Sri Lanka and hence model information need to be downscaled. There were a few attempts on downscaling and a brief review of the projected changes in climate in Sri Lanka due to global warming is presented in Box 3.

2.3. An Overall Assessment

Overall, information on observed and projected changes suggests that the climate of Sri Lanka is undergoing three major types of changes.

- Gradual increase in ambient air temperature
- Changes in distribution pattern of rainfall
- Increase in frequency and severity of extreme weather events

In addition to the above changes in atmosphere, there are associated changes in oceanic environment too, especially sea level rise, that seem to create significant impacts over Sri Lanka. Adaptation is a response strategy for overcoming the impacts of observed and projected changes in climate. Therefore, the above observations and projections provide the essential scientific basis for NAP.

Box 3: Projected Changes in Climate in Sri Lanka: Some Scientific Evidence

Three modelling approaches have been used for projecting climate change in Sri Lanka: general circulation models (GCM), regional climatic models (RCM) and statistically downscaled GCM models (Eriyagama et al., 2010). Key global projections applicable to Sri Lanka are projections for Asia in fourth and fifth assessments reports (AR4 and AR5) of IPCC. The general agreement of these projections is that South Asia will increasingly become warmer (Cruz et al., 2007; Hijioka et al. 2014). The warming is projected to be stronger than global mean in South Asia. Some of the predictions with high confidence (very likely) applicable for South Asia are: mean annual temperature will increase by greater than 3 Celsius; increase in precipitation by mid-21st century; increased precipitation extremes related to monsoons, and; oceans getting warmer in tropical Asia (Hijioka et al., 2014). Ahmed and Supachalasai (2014), based on a RCM, predicted that temperature could rise by 3.6 C, 3.3 C and 2.3 C under A2, A1B and B1 scenarios, respectively by 2080 (Table B-1).

Table B-1: Temperature and Precipitation Projections under Different Scenarios

Climate parameter	2030			2050			2080		
	A2	A1B	B1	A2	A1B	B1	A2	A1B	B1
Precipitation (%)	7.4	11.0	3.6	15.8	25.0	16.5	39.6	35.5	31.3
Temperature (C)	1.0	1.1	1.0	1.8	1.5	1.3	3.6	3.3	2.3

Source: Ahmed and Supachalasai (2014).

Like in the case of observed changes, projections also are less certain about the changes in rainfall pattern. Ahmed and Supachalasai (2014) predict increases in precipitation level by 39.6, 35.5 and 31.3 per cent, respectively, under A2, A1B and B1 scenarios by 2080 (Table B-1). However, locally downscaled models have predictions on change in precipitation towards both directions—increasing as well as decreasing mean annual rainfall (MAR) (Eriyagama et al., 2010). According to one projection, MAR will increase by 14 percent for A2 and 5 percent for B2 by 2050s compared with 1960-1991 (De Silva, 2006 b). This overall increase is not uniform and it predicts a decrease of 34 percent for A2 and 26 percent for B2 in NEM while projecting increases of 38 percent for A2 and 16 percent for B2 for SWM rainfall. Some studies have projected increased rainfall in wet zone, intermediate zones and north and south-western dry zones and decreased rainfall in other areas of dry zone by 2050 (Basnayake and Vithanage, 2004). Studies have also suggested a 17 percent reduction of rainfall in the upper Mahaweli watershed in the central highlands by 2025 (Shantha and Jayasundara, 2005). Another recent projection has predicted that climate pattern in Sri Lanka is getting more polarized where the Dry zone becomes drier and Wet zone becomes wetter in years to come (Marambe et al., 2015; Punyawardena et al., 2013 a).

The IPCC studies have also projected an increased incidence of extreme weather events for the South Asian region that may include heat waves and intense precipitation events (Cruz et al., 2007). Coastal disasters have also been projected to rise with increased incidence of tropical cyclones by 10-20 percent (Cruz et al., 2007).

3. Scope of the Plan and Key Stakeholders

Climate change is a complex phenomenon with impacts spread over all sectors of the economy and every strata of the society. Therefore, some scoping is necessary to identify and organize adaptation actions against climate change impacts. According to the UNFCCC guidelines, there are no standard frameworks proposed for scoping of impacts and organizing adaptation actions. Scoping of NAP has to be done according to the situation of respective countries.

A broad categorization of adaptation needs based on current understanding on climate change impacts as they are applicable in the context of Sri Lanka can be given as below:

- Adaptation needs of key sectors
- Cross-cutting national needs of adaptation

The NAP is intended to address both types of adaptation needs within a realistic timeframe. This section presents a brief description of two types of adaptation needs and the list of sectors and cross-cutting national issues identified in the consultation process of the NAP preparation. In addition, the section also identifies the key stakeholders of NAP and presents a comparison of the scope of the plan with the scopes of the National Climate Change Policy (NCCP) of 2012 and the National Climate Change Strategy (NCCAS) 2011-2016.

3.1. Adaptation Needs of Key Sectors

This refers to adaptation needs that can be handled within boundaries of vulnerable sectors. Consultations with key stakeholders and experts at the preparatory stage of the plan helped to identify nine critically important sectors in Sri Lanka in terms of vulnerability to climate change impacts and necessity of adaptive actions (Table 1). Usually, these sectors are serviced by established line ministries and agencies (e.g. Food security sector: Ministries for Agriculture/Livestock/Fisheries/Food Security and associated line agencies; health sector: Ministry of Health and line agencies). Consultations also helped in identifying the priority areas within each sector that needs specific actions of adaptation. In the identification of sectors and priority areas within them, attention was also given to align them with organizational structure of line agencies responsible for catering needs of respective sectors as far as possible.

Table 1: Key Sectors and Priority Areas

Sector	Priority areas
Food security : agriculture, livestock and fisheries	• Rice • Other food crops (OFC) • Horticultural crops • Sugarcane • Livestock • Fisheries • Agriculture and land degradation
Water resources	• Water for agriculture • Water for human consumption • Water for industry and energy • Degradation of watersheds
Coastal and marine sector	• Coastal zone management • Beach stability • Coastal bio-diversity • Ocean acidification
Health	• Climate altering pollutants • Diseases: Spread and outbreaks • Hazardous events: Health impacts • Heat/thermal stress
Human settlements and infrastructure	• Urban settlements and infrastructure • Rural settlements and infrastructure • Estate settlements and infrastructure • Coastal settlements and infrastructure
Ecosystems and biodiversity:	• Forests • Wild life • Wetlands • Agro ecosystems: home gardens • Loss of ecosystem services
Tourism and recreation	• Coastal tourism • Tourism and bio-diversity • Cultural assets
Export agriculture sector	• Tea • Rubber • Coconut • Export agricultural crops
Industry, energy and transportation	• Industry • Energy • Transportation

Mainstreaming approach implies that the climate change issues of these sectors should be handled by the respective line ministries and agencies themselves rather than by specialized agencies mandated for climate change. Simultaneously, the integrated approach implies that sectoral issues should be addressed with connection to national level issues. The NAP takes a facilitative approach towards sectoral adaptation needs through an institutional mechanism that involves respective line ministries/agencies mandated to address the needs of the respective sectors.

3.2. Cross-cutting National Needs of Adaptation

Cross-cutting national needs of adaptation are issues that pervade boundaries of the sectors. Overcoming gaps concerning these issues will help to increase adaptive capacities and reduce vulnerabilities of stakeholders in all or many sectors. As in the case of key sectors, cross-cutting areas have also been identified through the consultation of stakeholders and experts. The list of cross-cutting national issues and key areas of interest coming under them are given Table 2.

Table 2: Cross-cutting National Issues and Areas of Interest

Sector	Areas of interest
Policy, legal, economic and governance issues	• Policies and programs • Laws and regulations • Governance procedures
Institutional development and coordination	• Institutions • Coordination
International cooperation and partnerships	• International cooperation: global & regional • Areas for cooperation • Regional partnerships
Resource mobilization	• Resource mobilization : national sources • Resource mobilization : international sources • Resource mobilization: local (private & community) • Market based instruments
Research and development	• Research & development • Critical research needs • Research facilities • Skills and training needs
Technology transfer and standards	• Technology transfer: International dimension • Technology transfer: National and local • Channels of transfer • Standards

Building of adaptive capacity of communities	• Assessing adaptive capacity and vulnerability • Enhancing community participation • Utilization of local knowledge • Involvement of CSO • Change in attitudes, lifestyles and behaviour
Education, training and awareness	• Education (formal & informal) • Training needs and skills • Increasing awareness
Climate-induced disaster risk management	• Climate-induced disaster risks • Risk management instruments • Establish Connectivity to existing disaster management plans
Climate information management	• Climate forecasting: short-term & seasonal • Long-term projections • Communication of climate information

Climate change is a relatively new area of government intervention and there are no mandated national stakeholders vested with the responsibility of adaptation in respective cross-cutting areas except the CCS. At present the CCS, as the national focal point for the subject, is expected to look after many areas in spite of the Secretariat's limited capacity of doing so. Hence, identification of suitable national stakeholders and enlisting their support for planned interventions is a major challenge in implementing the plan. Responsibility of certain areas is already vested with national stakeholders (e.g. climate information - Department of Meteorology; disaster risk management – Disaster Management Centre). In such cases, the action plan should identify necessary capacity building interventions for the existing stakeholders whereas in others, the plan may need to come up with innovative solutions (e.g. institutional development and coordination).

3.3. Connectivity to and Consistency with other National Policies and Plans

3.3.1. Connectivity to National Climate Change Policy and the Strategy

The NAPs are supposed to have a connection with national visions/goals and to derive their legitimacy through instruments such as national policies, Acts of parliament, national directives, decree or executive orders by the head of state. Hence, attention was given to maintain consistency with the *National Climate change Policy of 2012* (the *Policy*) and the *National Climate Change Adaptation Strategy 2011-2016* (the *Strategy*) to the extent possible. It is necessary to position the NAP with respect to the *Policy* and the *Strategy.* However, the scope of the plan is not necessarily restricted by the scope of the *Strategy*.

National Climate Change Policy of 2012: The *Policy* articulates the broad national policy statements which will guide decisions taken at national and sub-national levels against the threat of climate change. It presents twenty five policy statements to cover a number of relevant areas of climate change in Sri Lanka including: vulnerability, adaptation, mitigation, sustainable consumption and production, knowledge management and general statements concerning institutional coordination, research and development, technology transfer, legal and regulatory framework, market and non-market based mechanisms and resource mobilization. Adaptation is only one component of the policy and there are other complementary areas that are linked to adaptation (e.g. vulnerability). Hence, the scope of the *Policy* is essentially broader than the scope of the NAP. However, the NAP expands and deepens the coverage of adaptation within the broader scope of statements adopted in the *Policy* and takes them into a level of practical implementation.

National Climate Change Adaptation Strategy (2011-16): The *Strategy* identifies strategic priorities required to be addressed when facing the threat of global climate change. The scope of the *Strategy* is restricted only to adaptation. Hence, it overlaps closely with the scope of NAP. Its scope covers five strategic thrusts, 25 thematic areas of action and 91 priority adaptation measures. Hence, it goes beyond identification of strategic priorities and suggests a broad selection of interventions to address these strategic priorities without specific plan of actions to implement them or to monitor the progress.

In relation to the *Policy* and *Strategy*, the role and function of NAP can be described as follows.

The NAP is a rolling plan with a set of implementable actions. It is not a statement of policies, strategies or principles, but a selection of practical interventions identified by relevant stakeholders to overcome anticipated threats due to impacts of climate change. It comprises a set of interventions selected by key stakeholders considered as desirable to overcome the perceived threats of climate change impacts in key sectors and cross-cutting national areas of interest. While the interventions of NAP are guided by broad principles laid down by the *Policy* and strategic priorities identified by the *Strategy,* it is not necessarily restricted by their scopes. Interventions identified in the NAP are focused actions with specific timelines, responsible stakeholders, implementation strategies and key performance indicators for monitoring and reviewing mechanisms compared with the broad interventions suggested by the *Strategy*. The interventions have been designed to mainstream climate change adaptation in the overall national effort for sustainable development, integrating decisions taken at supra- and sub-national levels as well. As in the case of *Policy* and *Strategy*, the NAP has also been developed through extensive consultation and participation of relevant stakeholders.

3.3.2. Connectivity to other National Policies and Plans

In addition to the *Policy* and the *Strategy* on climate change, the environment sector has a number of other national policies, strategies and action plans. Some of these policies have recognized climate change as a key environmental challenge faced by the country. Even though their coverage of the subject is not comprehensive and focused as in the current plan, they propose certain strategies, actions, projects for overcoming threats posed by climate change impacts on respective areas of interest. In this section, a brief review of most relevant policy documents is presented.

National Action Plan for Haritha Lanka Programme: The *Haritha Lanka Programme* has identified climate change as the third mission and selected certain strategies/actions relating to both mitigation and adaptation (NCSD, 2009). While the climate change mission in *Haritha Lanka* has given more weight to strategies/actions targeting mitigation (i.e. reducing GHG emissions), it has adaptation actions in areas of infrastructure vulnerability, land use zoning, rain water harvesting, increase of vectors and food security.

***Sri Lanka Comprehensive Disaster Management Programme 2014-2018* (SLCDMP):** The SLCDMP is a policy document, which has a close connection to the National Adaptation Plan (NAP). It identifies climate change as a disaster and proposes actions to overcome its' consequences. In addition, other major types of disasters identified by the SLCDMP such as floods, droughts, landslides, high winds/cyclones are also closely associated with extreme weather events. As a result, there are overlapping areas in the SLCDMP and NAP, however, the NAP does not intend to duplicate the SLCDMP. While proposing adaptation actions for extreme events in all sectors, the disaster risk management has been identified separately as a cross–cutting need of adaptation so that all disaster related actions can be coordinated closely with the existing disaster management agencies such as the Ministry of Disaster Management and the Disaster Management Centre.

***National Action Programme for Combating the Land Degradation of Sri Lanka* (NAP-CLD)**: The NAP-CLD has recognized climate change as a factor that can intensify the degradation of land resources in future (Ministry of Environment and Natural Resources, 2014). It highlighted issues such as soil erosion and landslides in up- and mid-country wet zone (upper watershed) areas as critical issues together with actions to overcome them. These actions can complement the climate change adaptation. Therefore, certain actions in the NAP-CLD and NAP can be jointly implemented through proper coordination.

***Coastal Zone Management Plan* (CZMP)**: The CZMP has also recognized climate change as a factor that can intensify the degradation of coastal resources in future. Its main concerns include coastal erosion, coastal pollution and degradation of coastal habitats. The NAP identifies impacts of climate change on the coastal sector and proposes adaptation measures to overcome them. Hence, overlapping areas of the CZMP and NAP are complementary and better results can be achieved through proper coordination.

***National Physical Plan* 2011-2030 (NPP)**: The NPP has identified global warming as a concern that can affect physical development activities of the country. In addition, it covers some aspects of disaster risk management too. However, the major focus of the NPP is development of physical infrastructure facilities and no attention was given to climate adaptation. However, its proposal to conserve central and coastal regions as environmentally sensitive (fragile) areas, complements achieving the objectives of the NAP to a certain degree.

***Sri Lanka Water Development Report 2010* (SLWDP)**: The SLWDP has identified climate change as a major driver of change in the water resources sector. However, information in the report suggests that there is no current policy, plan or programme in the water sector that specifically cover climate change adaptation. Hence, proposed actions of the NAP would be highly beneficial for addressing adaptation needs in the water sector.

Draft National Agriculture Policy: The presently available draft framework of the National Agriculture Policy for public comments identified 'Assuring food security' and 'Ensuring environment sustainability' as two major pillars of the policy in making. It recognized 'Natural resource management & climate change adaptation' as a key strategic/intervention area that cover soil conservation, water management, agriculture climate forecast and disaster risk reduction. However, the policy is still at the preliminary stage of preparation and the NAP has a comprehensive portfolio of actions under food security and water resources sectors that can complement the objectives of the National Agriculture Policy.

Overall, none of the existing plans or policies covers climate change adaptation as a special focus area. There are a few policy documents that cover climate change within their scopes in limited manner. However, they are focused on addressing specific issues of respective sectors/resources and climate change has usually been identified as an overarching issue that could affect respective sectors/resources. When preparing the NAP, other policy documents such as *Haritha Lanka, SLCDMP, CZMP and NAP-CDL* and *CNMP* also were taken into consideration and experts from respective sectors were consulted. Hence, the NAP, while being specialized and focused specifically on the subject of climate change adaptation, adopted a complementary approach towards other plans that cover climate change within their scope.

3.4. Consistency with Sri Lanka's global commitments on climate change

3.4.1. Consistency with INDCs

With the signing of Paris Agreement in April 2016 and ratifying the same in September 2016 by Sri Lanka, its global commitments on climate change will mainly focus on the INDCs that have been already submitted. Sri Lanka's submitted INDCs are mainly covered the areas of mitigation, adaptation, loss and damage and means of implementation. In this contest INDCs related to adaptation cover the sectors of; human health, food security (agriculture, livestock and fisheries), water, irrigation, coastal and marine, biodiversity, urban city planning & human settlements, and tourism & recreation. Each of these sectors has separate sectoral INDCs.

All these sectors have been covered in the NAP. In addition, it also covers adaptation needs of export agriculture sector along with industry/transport/energy sectors which comprises main mitigation sectors in Sri Lanka's INDCs. Moreover, nearly all sectoral INDCs have been captured under different adaptation options and adaptive actions proposed to address respective sectoral needs of adaptation. The submission on INDCs acknowledges the NAP, all technical work of which had been completed by the time of submission (April 2016) and identifies it as a source document for identifying key sectors and sectoral INDCs. Hence, the connectivity between the NAP and Sri Lanka's INDCs is straightforward and there is high level of consistency between the two. In fact, even though official submission of INDCs came first, they are directly based on and guided by the NAP. This implies that implementation of the NAP will complement fulfilling Sri Lanka's global commitments on climate change and vice versa.

The NAP also contributes to SDGs and an assessment on the contribution of NAP to achieve SDGs is presented in Section 8.

3.5. Key Stakeholders of the Plan

Like many other national plans, the NAP has also been prepared to implement within the organizational structure of line ministries and line agencies of the Government of Sri Lanka. However, its target beneficiaries are not the government agencies, but the vulnerable sections of the society to climate change impacts. The ultimate goals of the plan are to enhance the adaptive capacity of these target groups and reduce the state of vulnerability they are currently in. These ultimate goals, however, have to be delivered through the joint efforts of key stakeholders that include:

- Government sector (Line ministries and line agencies and central government and

provincial councils)
- Private sector (Corporate sector and SMEs)
- Civil society organizations
- Academics, researchers and other knowledge makers
- Local community-based organizations

While these stakeholders bear implementation and monitoring responsibilities of the plan in their professional and occupational capacities, individually they are also part of vulnerable sections of the society to climate change impacts. Hence, they have vested interests of being a part of target beneficiaries as well that should give additional source of motivation for making the plan a success.

4. Planning Concepts and Approaches

The plan is guided by the principles adopted by the *Policy,* the *Strategy* as well as the NAP guidelines developed by UNFCCC. Being a more practically oriented document, it is more concerned with planning concepts and approaches that underline the preparatory elements of the plan. The key planning approaches and concepts used are:

- Mainstreaming adaptation to national development
- Integration of sectoral and cross-cutting national dimensions
- Adaptive policy and management
- Anticipatory adaptation

Mainstreaming adaptation to national development: The NAP aims to mainstream the climate change adaptation to sustainable development of the country. The term 'mainstreaming' implies fulfilling a few essential conditions as given below.

*Prioritized***:** Adaptation to climate change impacts should be given due priority among other national issues at macro and sector levels that compete for policy makers' attention.

*Comprehensive***:** Plan should cover a comprehensive scope to address key priority areas concerning climate change impacts in Sri Lanka

*Informed***:** Decisions/actions should be taken with consultation of the best available information at the time of decision

*Timely attended***:** Issues pertaining to climate change should be addressed on a regular basis taking required decisions/actions at the right time

*Ensured with sufficient resources***:** Necessary resources for implementation of planned interventions should be provided in adequate amounts in a timely manner

*Coordinated***:** All actions should be taken with appropriate level of coordination among relevant stakeholders

Success of mainstreaming climate change adaptation to national development process would be determined by how successfully the above conditions shall be fulfilled by the plan of actions.

Integration of sectoral and macro dimensions: Climate change is a complex phenomenon that gives rise to sectoral and cross-cutting adaptation needs among sectors. Therefore, planned interventions should be integrated to address impacts and vulnerabilities that arise at different sectors as well as cross-cutting needs that may spread across boundaries of several sectors. It is the role of NAP to ensure that all necessary sectoral and macro dimensions of climate change impact are covered and arrangements are in place to integrate relevant sectors when impacts and adaptation options concerned are interconnected among sectors.

Adaptive policy and management*:* Uncertainty is the key challenge that has to be faced in making any form of planned intervention against climate change impacts. A policy dilemma arise here as no one can accurately predict future scenario(s) whereas decisions also cannot be delayed awaiting more information before it is too late. Therefore, adaptive policy making and management principles should be adopted here. This implies that: (a) selected interventions should be robust and resilient to a wide range of future scenarios and, (b) decision making process should be flexible to make adjustments according to emerging information.

Anticipatory adaptation: Climate change is an ongoing process. Policy makers can either take decisions in advance anticipating future impacts (anticipatory adaptation) or they can wait till impacts appear (reactive adaptation). Given the uncertainty involved in the whole process of climate change, reactive responses carry an immense risk. Therefore, the NAP adopts the principle of anticipatory adaptation.

5. Planning Methodology

The methodology of the plan was guided by the broad framework proposed by UNFCCC guidelines on the NAP process (Figure 1). Accordingly, the real planning activities of the NAP process are covered under the second stage on 'preparatory elements'. The essential preparatory elements identified in the NAP process include: analysing current climate and future climate scenarios; assessing vulnerabilities; identifying, reviewing and appraising adaptation options; and, compiling and communicating national adaptation plan.

The methodology of the plan was developed to cover these essential elements and the key steps of the methodology included the following:

- Assess the projections on major changes in atmospheric and oceanic systems that are important for Sri Lanka
- Determine different physical effects/dimensions of change associated with the major projections
- Identify key physical hazards and vulnerabilities on major sectors caused by physical effects of projected changes
- Recognize likely impacts and their socio-economic outcomes on respective sectors and stakeholders
- Recognize adaptation needs of sectors, determine appropriate adaptation options to fulfill these needs and identify necessary actions to achieve these options
- Figure out cross-cutting national adaptation needs through the analysis of sectoral information and consultation of stakeholder views
- Identify interventions necessary for fulfilling cross-cutting national adaptation needs

These key steps were followed through an extensive series of consultations and analysis of inputs collected in the process.

5.1. Methodology of the Plan

The following activities were carried out to cover the methodological steps of the plan.

Review of available information: Information available from various sources on climate change in Sri Lanka was reviewed. The review also covered similar plans (e.g. climate change action plans; adaptation plans, NAPAs) prepared by other countries. IPS has already developed a significant understanding on climate change policy issues in Sri Lanka through research studies conducted during the last few years. It has recently conducted a policy analysis on key sectors using expert elicitation method for which the staff of CCS also was regularly invited. Inputs from review of literature, IPS own research as well as knowledge acquired from consultation of experts was used as background information for preparation of the plan.

Initial brainstorming sessions: Two brain storming workshop sessions were conducted for identifying the methodology and finalizing the scope of the plan. A UNFCCC expert was invited to the first workshop on methodology for better understanding on the UNFCCC guidelines on NAP process. These sessions were followed by discussions between consultants, CCS staff and UNDP staff helped to develop the seven step methodological framework given above.

Consultations: Consultants developed a structured discussion guide based the methodological framework developed and conducted nine consultation meetings participated by government officers, academics, CSO members and experts on each sector. These discussions were the main data collection activity involved in preparation of the plan. In the discussions, inputs of participants were systematically gathered on: projections on major changes in atmospheric and oceanic systems; different physical effects of those projections; key physical hazards and vulnerabilities affecting respective sectors; likely impacts and their socio-economic outcomes; adaptation needs of sectors and appropriate adaptation options, and; actions necessary to achieve the options. In addition, one workshop was conducted to gather stakeholders' opinions on the cross-cutting needs of adaptation.

Analysis and preparation of the draft plan: Information gathered in discussions was analysed using qualitative analytical tools. Based on the outcomes of analysis, the first complete draft of the plan was developed. This was submitted for comments and feedback of CCS staff. Revised draft was distributed to stakeholders for their comments.

Preparation of the final draft: The final draft of the plan was prepared by incorporating comments and suggestions offered by stakeholders in a final validation workshop.

6. Projections, Physical Effects, Impacts, Adaptation Needs and Adaptation Options

This section presents a detailed summary of projections, physical effects, impacts, adaptation needs and adaptation options identified for each sector. Adaptation action plans for each sector presented in the next chapter were developed based on these summaries.

Stakeholder consultations helped to identify projections on five major types of changes in atmosphere and oceanic systems that could create impacts on vulnerable sectors. They are:

- Increased atmospheric concentration of greenhouse gases
- Rising atmospheric temperature
- Changing pattern of precipitation
- Increased incidence and severity of rainfall
- Sea level rise

These projections have different physical effects (dimensions) that create impacts on respective sectors. These physical effects involve different time horizons and it seems many are already in effect or could take place in the short run. There are also physical effects that may take time to show their effects gradually. Table 3 presents the physical effects identified for each type of projections.

Table 3: Projections and their Physical Effects

Projections	Physical effects/dimensions	Time horizon
Increased concentration of GHG	Rising atmospheric CO_2 concentration	Short-term
	Increased concentration of climate altering pollutants (non-CO_2)	Short-term
	Progressive increase in acidity of rainfall	Long-term
	Ocean acidification	Long-term
Rising atmospheric temperature	Increased day and night air temperature	Short-term
	Increased evaporation and evapotranspiration	Short-term
	Alteration of optimal ranges of temperature for biological organisms (pests, pathogens, parasites, vectors)	Medium-term
	Increased concentration of dust/ soil particles in atmosphere	Short-term
	Heat island effect	Short-term
Rising oceanic temperature	Physio-chemical changes in oceanic environment	Long-term
Changing patterns of precipitation	Irregular/erratic changes in established patterns of rainfall	Short-term

	Regular incidents of intense rainfall with high cloud cover	Short-term
	Regular and extended dry spells	Short-term
	Boundary shift in climatic zones	Long-term
Increased incidence and severity of extreme events	Increased frequency and severity of floods	Short-term
	Increased frequency and severity of droughts	Short-term
	Increased frequency of cyclones and high winds	Short-term
	Increased incidence of lightening	Short-term
	Increased incidence of landslides	Short-term
	Increased wind and waves (Turbulent weather)	Short-term
Sea level rise	Salt water intrusion	Medium -term
	Inundation of low-lying areas	Long-term

These physical effects create hazards and vulnerabilities on different sectors. These physical hazards and vulnerabilities are the root causes of sectoral impacts. They could create multiple impacts on sectors with socio-economic outcomes. Experts suggested that the same physical effects could lead to create different impacts on different sectors. Similarly, physical effects could act in combination with each other on different sectors. For instance, rising temperature would lead to create pronounced impacts on crops and natural biodiversity together with periodic dry spells or droughts, generating losses to farmers and peripheral communities around forest. Likewise, the same combination of physical effects could affect urban communities negatively by decreasing their living comfort, causing them to spend more on domestic cooling facilities. Identification of potential impacts on different sectors was the most important step for selection of respective adaptive actions for different sectors. This was done through lengthy and exhaustive expert consultation sessions where available limited information was screened by experts applying their professional knowledge as groups to reach consensus on types of impacts.

Adaptation needs of different sectors are determined by the impacts and their socio-economic outcomes. Depending on the types of impacts, sectors could have a number of adaptation needs. Adaptation options are broad solutions available to fulfill those adaptation needs of different sectors. Each adaptation option may involve several actions which are practical measures of adaptation that help to build up the adaptive capacity and reduce vulnerability of stakeholders in each sector. Summary of physical effects, vulnerabilities/physical hazards, impacts, socio-economic outcomes, adaptation needs and adaptation options identified for nine sectors are presented in Appendix Tables A1-A9.

Overall analysis of summary tables helped to identify cross-cutting national needs of adaptation that help to build up the adaptive capacity of all or many sectors simultaneously. In the next chapter, adaptation action plans developed for each sector and the plan for cross-cutting adaptation actions are presented.

7. The Plan

The NAP is the country's road map to guide the national efforts for confronting challenges posed by global climate change and its impacts. It envisages moderating and coping up with harmful impacts of climate change while taking the advantage of any opportunities presented in the path. It offers a practical path of action to reduce the vulnerability and enhance the adaptive capacity of the nation as a whole.

The NAP consists of action plans for nine vulnerable sectors and a set of interventions proposed to fulfill cross-cutting national needs of adaptation. Among the key components covered in the NAP are: specific actions/interventions with time lines to fulfill sectoral and cross-cutting adaptation needs; an implementation strategy for selected interventions; institutional mechanisms for coordination of actions of stakeholders; key performance indicators (KPI) for each action; system for monitoring and evaluation KPIs.

7.1. Goals

The NAP aims at achieving Sri Lanka's objectives of sustainable development through appropriate, timely measures of adaptation so as to ensure a secure future for its citizens by minimizing the impacts of climate change on human life, ecosystems, national assets and the economy.

The major goals of the plan are to:

- Raise the adaptive capacity of individuals, communities and the society to cope with impacts of climate change effectively;
- Reduce the vulnerability to climate risks by enhancing the resilience of communities and ecosystems, and;
- Capture any opportunities that arise due to changes for maximum gain for the society and people.

7.2. Objectives

The plan intends to reach these broader goals through achieving the following objectives.

1. To increase the resilience of economic sectors and natural systems against the emerging and projected impacts of climate change by adopting appropriate coping strategies and system improvements
2. To minimize the risk of damage caused by short-, medium- and long-term impacts

associated with projected changes in climatic parameters through timely adaptive measures
3. To expand the current knowledge on observed and projected changes of climate and associated physical vulnerabilities and socio-economic impacts through scientific research
4. To build the capacity of communities, economic sectors and ecosystems to adjust more readily to unfolding changes of climate through supportive investments on adaptive actions and increased awareness
5. To improve the existing systems of disaster risk management to minimize the vulnerabilities and increase the risk preparedness for extreme events
6. To increase the preparedness to face the threats of climate change through establishment of advanced monitoring and surveillance systems, timely weather and climate forecasting systems and effective communication channels for information dissemination
7. To increase the skills and knowledge on successful practices of adaptation through well-designed education, training and awareness programmes

7.3. Time Plan of Actions

Time horizon of the plan is ten years extending from 2016 to 2015. This period is divided into three stages for periodic revision of the plan according to the following timeframe.

Table 4: Time Horizons of the Plan

Period	Stage of the Plan	Review
1-4 years (2016 -2019)	Foundation building stage	Progress of the first stage to be reviewed at the last quarter of 2018 and necessary adjustments be made
5-7 years (2020 -2022)	Development stage	Progress of the both stages since 2015 to be reviewed at the last quarter of 2021 and necessary adjustments to be made
8-10 years (2023- 2025)	Goal achieving stage	Progress of the whole plan to be reviewed at the first quarter of 2025 and gaps and lessons for future plans to be identified

7.4. Summary of the Overall Plan

Table 5 presents an overall summary of the plan. It presents a list of actions that were assigned the highest priority by stakeholders from respective sectors and the priority actions identified for overcoming the cross-cutting adaptation needs. Priority was determined by ranking offered by individual experts and working groups on respective sectors in the validation workshop. The detailed action plans for respective sectors and cross-cutting needs of adaptation are presented in Tables 6-15.

Table 5: An Overall Summary of the Plan - Priority Actions

Sector	Priority actions
Food security	• Develop tolerant varieties (paddy, OFC, horticulture) and breeds (livestock and poultry) to heat stress, drought and floods and resistant to diseases and pest attacks • Develop and promote water efficient farming methods • Adjust cropping calendars according to climate forecasts • Develop systems for timely issuing and communicating of climate information to farmers • Develop research institute capacity for conducting research on tolerant varieties/breeds and climate resilient farming methods
Water resources	• Develop and implement watershed management plans for critical watershed areas • Increase the efficiency of use and reduce losses of irrigation water • Assess the current practices of water management for climate resilience and identify ways to improve them • Identify and map areas vulnerable to droughts and flood hazards and prepare disaster risk management plans • Design rational intra-basin and trans-basin strategies to harness periodic surpluses of water in storage facilities
Coastal and marine sector	• Implement a continuous programme for monitoring shore line changes • Develop shore shoreline management plans including M&E programmes • Study impacts of sea level rise on costal habitats over short-, medium- and long-term horizons • Identify, declare, collect information and prepare maps on vulnerable areas to extreme events and inundation • Conduct awareness programmes on sea level rise and extreme events to coastal communities to empower them for facing the risks of climate change
Health	• Establish a surveillance programme for detection and monitoring of climate induced diseases • Conduct research studies on impact of climate change prevalence and spread of vector borne and pathogenic diseases • Develop research institutes' capacity conducting research on health impacts of climate change • Strengthen the mechanisms for sharing information between disaster management and health management agencies • Launch awareness programmes on climate and health risks for healthcare workers and the public

Human settlements and infrastructure	• Promote climate resilient building designs • Revise building approval systems to increase the climate resilience • Conduct research studies on climate resilient building designs, green building concepts and alternative materials • Conduct training programmes on climate resilient buildings for industry stakeholders • Prepare hazard preparedness plans for urban, rural and estate settlements
Ecosystems and biodiversity	• Conduct research studies on climate change impacts on ecosystems and biodiversity • Establish a comprehensive programme to monitor climate change impacts on key natural ecosystems and biodiversity • Prepare adaptive management programmes for climate sensitive ecosystems • Prepare recovery plans for highly threatened ecosystems and species • Develop research institutes' capacity for conducting research on climate change impacts on ecosystems and biodiversity
Tourism and recreation	• Increase the awareness of tour industry operators on climate change and its impacts • Establish emergency communication channels for tourists and operators • Identify tourism facilities in vulnerable areas and make arrangements to increase the climate resilience of them • Assess the current promotional strategies with connection to emerging scenarios of climate change and adjust them accordingly • Conduct research studies on climate change impacts on tourism and recreation
Export agriculture sector	• Introduce new cultivars/clones tolerant to heat, drought and flood and resistant to disease and pest attacks • Promote improved nursery and plant management practices and sustainable cropping systems to increase the climate resilience of plantations and crops • Conduct research studies on climate change impacts on export agriculture crops • Identify and collect information on areas most vulnerable to disasters and prepare hazard vulnerability maps for all crops • Develop research institutes' capacity for conducting research on climate change impacts on export agriculture crops

Industry, energy and transportation	• Minimize the fluctuation hydropower generation potential through improvements in system management • Diversify the energy mix with increased share of renewable energy • Diversify the supply sources of climate sensitive agro-based raw materials • Establish an early warning and hazard communication system for commuters and managers of energy, transport and industrial facilities • Conduct research studies on climate change impacts on industry, energy and transportation
Cross-cutting needs of adaptation	• Undertake a review of relevant macro and sectoral policies, ordinances, acts, statutes and procedures to identify options for mainstreaming climate change adaptation activities in Sri Lanka • Develop policy recommendations necessary for addressing vulnerability to impacts of climate change in all development /management projects
	• Restructure and strengthen the Climate Change Secretariat as the National Focal Point (NFP) for implementation of NAP
	• Develop an inventory of international climate donors, funding schemes, training providers, training programmes, research agencies/consortiums and events (conferences, seminars etc.) for the benefit of local stakeholders of adaptation
	• Create a *National Adaptation Fund* with the collaboration of the Ministry of Finance to support the implementation of NAP actions and supportive programmes
	• Establish a national network of research agencies and universities that are carrying out research on climate adaptation for promoting coordinated research and information dissemination • Develop a coordinated multi-disciplinary small research grant programme on thematic areas relating to climate change adaptation to be facilitated by the National Focal Point and managed by the national research support agencies (e.g. NSF, NRC, CARP) • Establish a common repository of scientific and awareness materials on climate change adaptation
	• Initiate a joint island wide programme for identification of religious, cultural and archaeological assets vulnerable to climate change impacts and conservation of threatened assets
	• Conduct training programmes for government officers, CSO members, and private sector employees on climate change adaptation • Establish a national research programme on climate modeling for long-term climate projections

7.5. Sectoral Adaptation Plans

Sectoral action plans contain adaptation actions/interventions proposed to fulfill adaptation needs of nine identified sectors. These sectors were identified for their high level of vulnerability to impacts of climate change. The actions of sectoral plans have been chosen to fulfill adaptation needs of the sectors which have been identified on a logical criteria based on projections, vulnerabilities and impacts on respective sectors. Details on identification of adaptation needs are presented in Appendix Tables A-1 to A-9. Action plans begin with adaptation needs and provide details on actions, responsible agencies and key performance indicators. The specific institutional and implementation mechanisms proposed for implementation of sectoral plans are presented in forthcoming sections of the plan. Tables 5-14 present the actions plans for each sector.

Food Security

Food security is one of the most critical areas that need special attention in climate adaptation in Sri Lanka. Key components that contribute to food security in Sri Lanka are rice, other food crops, fruits and vegetables (horticultural crops), animal production and fisheries. The country has achieved self-sufficiency in rice. However, the country depends on imports for a number of other food products. Hence, agriculture development efforts in the country are mainly targeted at achieving self-sufficiency or reducing the import dependency of at least main categories of food such as milk and milk products and sugar. Relative contribution of the agriculture sector to the national economy has reduced to around 10 per cent of GDP. However, agriculture still occupies around 30 per cent of the workforce and a significant share of farmers live under poverty. Of all the economic sectors, agriculture is the most climate sensitive sector and climate related hazards have significantly affected the agricultural production and farm assets during the recent past. Hence, high climate sensitivity and livelihood dependency of a large section of population makes food security a highly vulnerable sector to climate change impact that needs special attention in national adaptation plan.

Table 6: Sector Action Plan – Food Security

Adaptation needs	Adaptation options	Actions	Responsible agencies	Key performance indicators
Enhance the resilience of crops, animals, fish and agro-ecosystems against heat and water stress	A. Germplasm improvement	• Screen existing varieties/breeds for heat and water stress. • Develop tolerant varieties (paddy, OFC, horticulture) – Heat tolerant – Drought tolerant – Short age (early maturing) • Develop heat tolerant breeds (**Focus**: livestock and poultry)	**DOA** **DAPH** *AFoU* *VRI* *NLDB*	• Number of existing varieties/breeds gone through the screening process • Number of tolerant varieties developed • Number of heat tolerant breeds developed
	B. Improvement of farm water management	• Reduce field-level irrigation water losses • Promote micro-irrigation techniques • Develop water efficient farming methods • Promote on-farm rainwater harvesting • Promote reuse of wastewater	**DOA** *AFoU* *DI* *DAD* *MASL*	• % of reduction in irrigation water losses • Number of micro-irrigation initiatives • Number of water efficient farming methods developed • Number of on-farm rainwater harvesting initiatives
	C. Promotion of resource efficient farming systems	• Improve cropping systems and conservation farming practices • Improve nursery protection • Introduce flower induce techniques in fruits • Increase the use organic matter to improve soil quality (Integrated plan nutrient management) • Promote low-water demanding crops and varieties and crop diversification (**Focus**: Dry and intermediate zones) • Promote the intensive management of livestock	**DOA** **DAPH** *AFoU* *VRI*	• % increase in the yield due to improve cropping systems and conservation farming practices • % drop in the nursery plant losses • Number of flower induce techniques introduced • % increase in the use of organic matter
	D. Sectoral Capacity development	• Develop research institutes' capacity for conducting research on tolerant varieties and water efficient farming methods.	**NSF** *DOA* *VRI* *SLCARP* *AFoU*	• Number of training programme

Minimize the risk of crop and health damage due to biological agents	A. Germplasm improvement	• Screen existing varieties/breeds for pest and disease resistance. • Develop pest resistant varieties (**Focus**: paddy, OFC, horticulture; insect pests and diseases) • Develop disease resistant breeds (**Focus**: livestock and poultry)	**DOA** **DAPH** *AFoU* *VRI* *NLDB*	• Number of existing varieties/breeds gone through the screening process • Number of pest resistance varieties developed • Number of disease resistant breeds developed
	B. Strengthening of supporting facilities	• Strengthen vaccination programmes • Develop pest forecasting system • Conduct research on parasites and diseases • Promote crop clinics	**DOA** **DAPH** *VRI*	• Amount of money allocated for vaccination programme • Pest forecasting system developed • Number of research outputs o parasites and diseases
	C. Promotion of best practices	• Promote integrated pest management	**DOA** *AFoU*	• Number of awareness programmes on integrated pest management
Minimize the impact on food security due to erratic changes in precipitation	A. Establishment of an efficient climate information management and communication system	• Develop a system for timely issuing of seasonal and medium-term weather forecasts (**Focus**: mobile and internet alert systems) • Adjust cropping calendars according to the seasonal weather forecasts	**DM** *DOA* *DAPH*	• System is developed • Cropping calendars adjusted
	B. Improvement of pasture and fodder management	• Diversify into livestock feeds other than naturally grown pasture • Promote silage and hey production • Promote techniques of fodder production and conservation	**DAPH** *VRI* *NLDB*	• Number of other types of livestock feeds adapted • Number of research carried out to suggest other livestock feed types • Number of awareness programmes on silage production • Number of techniques promoted • Amount of money allocated for promotion of fodder production and conservation techniques
Enhance the resilience of crops, animals, fish and agro-	A. Germplasm improvement	• Screen existing varieties for tolerance to extreme events • Develop tolerant varieties (**Focus**: paddy) – Flood tolerant – Drought tolerant	**DOA** *AFoU*	• Number of existing varieties gone through the screening process • Develop flood and drought tolerant varieties

ecosystems to extreme weather events	B. Establishment of an efficient climate information management and communication system	• Develop a system for timely issuing of short-term weather forecasts • Strengthen the early warning systems • Strengthen fishing Vessel monitoring and tracking system (**Focus**: Coastal and deep sea fishing) • Develop mobile phone based communication systems • Develop safety plans and promote use of safety equipment	**DM** *DOA* *DFAR* *DAPH*	• Forecasting system developed • Money allocated for strengthening the early warning system • Fishing Vessel monitoring and tracking system established • Mobile phone based communication system developed • Safety plans are developed • Number of awareness programs on the use of safety equipments
	C. Improvement of disaster risk preparedness and management	• Identify and collect information on areas most vulnerable to flood and drought hazards • Identify food storage capacities in vulnerable areas • Develop buffer stocks and maintain them regularly	**DMC** **DFC** *DCD* *PMB*	• Number of areas where the Information collection is finalized • Number of food storage capacities are assessed identified • Number of vulnerable areas with established buffer stocks
Minimize the impacts of sea level rise on agriculture in coastal zone	A. Germplasm improvement	• Screen existing varieties for tolerance to salinity/alkalinity • Develop salinity/alkalinity tolerant varieties (**Focus**: paddy)	**DOA** *AFoU*	• Number of existing varieties gone through the screening process • Number of salinity tolerant varieties developed • Data base with quarterly salinity levels in the coastal areas • Money allocated for rehabilitation of the salinity exclusion structures • Number of the salinity exclusion structures rehabilitated • Number of paddy acres converted
	B. Strengthening the monitoring of climate impacts	• Monitor regularly the development of salinity /alkalinity levels • Strengthen the seawater defense structures to control sea water intrusions to coastal paddy lands	**CC&CRMD** **NARA** *DOA* *ID*	
	C. Exploring alternatives	• Convert severely affected paddy lands for other uses (e.g. brackish water aquaculture)	**NAQDA** *DOA* *DAD*	
Assess the changes in oceanic environment and impacts on livelihood	A. Initiating research studies to assess climate impacts	• Assess long-term structural changes oceanic habitats and composition of species • Assess climate change impacts on lagoon and coastal fisheries • Assess climate change impacts on reef fish stock	**NARA** *AFoU/SFoU* *NSF* *NRC* *CARP*	• Completion of the assessment (long-term structural changes oceanic habitats and composition of species) and report made available • Completion of the assessment (climate change impacts on lagoon and coastal

and food security	B. Strengthening the monitoring of climate impacts	• Initiate long-term monitoring of essential bio-physical parameters (National monitoring programme)	**NARA** *CC&CRMD*	fisheries) and report made available • Completion of the assessment (climate change impacts on reef fish stock) and report made available • A monitoring system for essential bio-physical parameters is established
Assess the impacts of rising atmospheric CO_2 on productivity crops and weed populations	A. Initiating research studies to assess climate impacts	• Conduct research studies on impact of increased CO_2 on agriculture – Productivity of crops – Weed populations (**Focus**: Invasive alien species)	**DOA** *AFoU/SFoU* *NSF* *NRC* *CARP*	• Number of research studies conducted • Amount of money spent on research

Water Resources

Availability, supply, distribution, use and conservation of water resources are directly dependent on climate conditions. The water resources sector in Sri Lanka has to cater to the domestic, agricultural and industrial needs of water. Besides fulfilling human needs, the survival of all ecosystems also relies heavily on the availability of water. Relationship between water and ecosystems is a complex one. Hence, in addition to fulfilling human needs, managers of water resources have to be mindful about ecosystems also. Only a limited segment of households in the country have access to safe drinking water. Sri Lanka has invested heavily on agricultural water supply and a significant share of the country's power generation capacity also is dependent on water resources. A growing number of industrial facilities also create demand for water resources and this has led to high level of extraction of groundwater as well as increased pollution of water resources. Overall, water is an important sector that has implications for all major economic sectors and human activities that need special attention in adaptation climate change.

Table 7: Sector Action Plan – Water Resources

Adaptation needs	Adaptation Options	Actions	Responsible agencies	Key performance indicators
Enhance the resilience of systems for water resources management and use to overcome the scarcities caused by climate change impacts	A. Improvement of watershed management	• Identify and map critical watersheds • Develop and implement watershed management plans for critical upper watersheds – Declare critical catchments as reserves – Incorporate water safety plans • Increase the canopy cover in catchment areas of – Irrigation reservoirs – Water supply reservoirs – Hydropower reservoirs • Promote conservation farming methods in reservoir catchments • Launch participatory cascade management programmes in selected village tank catchments • Incorporate climate impact assessment for the future water resources development plans	**ID** **MASL** **DAD** *CEB* *NWSDB* *WRB* *PCs*	• Number of watershed plans developed • % of canopy cover increased in the catchment areas of irrigation and water supply reservoirs • Number of conservation framing methods adopted • Amount of money allocated/spent on promotion of conservation farming methods • Number of workshops carried out in promotion • Number of villages covered by the participatory cascade management programmes • Amount of money allocated/spent on participatory cascade management programmes
	B. Capacity development of storage facilities	• Assess the current facilities and storage options in connection to future projections of climate change • Evaluate future options for enhancement of storage facilitates including groundwater • Develop a road map and investment plan for efficient utilization of existing and future storage options • Assess, regularize and preserve ground water resources at local level water resources for effective utilization	**ID** **MASL** **DAD** *AFoU* *NWSDB* *WRB* *IWMI*	• Number of current facilities and storage options assessed • An assessment report is finalized and made available on the current facilities and storage options • Number of options evaluated • A road map and an investment plan is developed.

	C. Initiating research studies to assess climate impacts	• Assess short-, medium- and long-term impacts of climate change on water resources management in the country • Screen current practices of water management for climate resilience and identify ways to improve them • Explore climate resilient indigenous practices of water management and identify ways to integrate them into modern practices	**ID** **MASL** **DAD** *DM* *IWMI* *AFoU/SFoU* *NSF* *NRC* *CARP*	• An assessment report completed and published • Number of screened water management practices for climate change resilience • Number of indigenous practices of water management identified and integrated
	D. Strengthening the monitoring of climate change impacts (changing pattern of variability)	• Initiate a long-term monitoring programme on essential bio-physical parameters of climate change on water resources – National monitoring programme	**CEA** *DM* *ID* *MASL* *DAD* *IWMI* *NWSDB*	• Monitoring programme is installed and functioning
	E. Promote efficient practices of water management and use	• Promote efficient domestic water use practices: – Domestic rain-water harvesting systems (e.g. ferro-cement tanks; roof top) – Domestic water treatment facilities • Increase the efficiency of use and reduce losses of irrigation water – Re-use of drainage (waste) water – Water saving irrigation applications: micro irrigation, drip irrigation – Efficient use of groundwater: Production wells , boreholes – Rainwater harvesting: *Pathaha* • Improve maintenance of existing reservoirs – Improve the water conveyance efficiency – Rehabilitation of village tanks to design capacity • Promote wastewater recycling for industrial and aquaculture water uses	**ID** **MASL** **DAD** *IWMI* *NWSDB* *DOA*	• Number of awareness campaigns launched to promote efficient domestic water use practices • Money allocated/spent on promoting efficient domestic water use practices • Number of awareness campaigns on promoting means of reducing wastage and losses in irrigation • Money allocated/spent on promoting means of reducing wastage and losses in irrigation • Money allocated/spent on improving the maintenance of existing reservoirs • Number of village tanks rehabilitated • Number of village tanks with improved conveyance efficiency

Ensure the safety of water management facilities and minimize disturbances to supply due to extreme weather events	A. Strengthening the monitoring of climate change impacts (extreme events)	• Assess the capacity of existing hydro-meteorological information facilities • Implement necessary capacity improvement measures (**Focus**: facilities in water management agencies)	**DM** *ID* *MASL* *DAD* *NWSDB* *DOA*	• Number of assessments completed out of existing hydro-meteorological information facilities • An assessment report is completed and published • Number of initiatives implemented
	B. Establishment of an efficient climate information and communication system	• Improve the existing system for timely issuing short term weather forecasts • Strengthen the early warning systems • Develop network based communication systems (**Focus**: mobile phones and internet) • Assess the traditional knowledge of weather forecasting and integrate them for better forecasts of water availability.	**DM** *ID* *MASL* *DAD* *NWSDB* *DOA*	• A system is developed • Money allocated/spent on strengthening the systems of short-term weather forecasts A mobile phone based communication is in place • Money allocated/spent on developing the mobile phone based communication system • An assessment study is completed and report published on traditional knowledge of weather forecasting • Number of training programmes/workshops conducted on integrating traditional knowledge of weather forecasting in to existing one
	C. Improvement of disaster risk preparedness and management	• Identify, map and collect information on areas most vulnerable to flood , drought and land slide hazards • Develop disaster risk management plans for vulnerable areas • Establish necessary facilities for improvement of drainage in susceptible areas • Develop dam safety plans and promote use of safety measures and equipment	**DMC** **NBRO** *ID* *MASL* *DAD* *NWSDB* *DM*	• Number of areas identified and completed with data collection • Number of areas completed with finalized flood risk management plans • Number of areas with established facilities for improvement of drainage • Number of dam safety plans developed

	D. Capacity development of storage facilities	• Design rational strategies to harness excess water in storage facilities (**Focus**: Intra-basin and trans-basin approaches)	**ID** **MASL** **DAD** *AFoU* *NWSDB* *DM*	• Number of strategies designed to harness the excess water in storage facilities. • Number of workshops/training programmes on designing strategies to harness the excess water in storage facilities
Minimize the impacts of sea level rise on water supply and management in coastal zone	A. Strengthening the monitoring of climate change impacts (sea level rise)	• Monitor salinity levels regularly	**NARA** **CC&CRMD**	• Money allocated/spent on developing the monitoring system • Regular (quarterly) monitoring reports prepared and presented
	B. Improve saltwater intrusion protection measures in coastal areas and wetlands	• Identify vulnerable areas for saltwater intrusion and develop maps • Strengthen the salinity exclusion structures to control sea water intrusions • Design and construct salinity barriers to protect fresh water resources and agricultural lands • Establish desalinization facilities in affected/vulnerable areas	**CC&CRMD** *ID* *DAD* *NWSDB* *DA* *NARA* *NAQDA*	• Number of vulnerable areas identified and plans developed • Number of salinity exclusion structures rehabilitated/repaired/newly built • Amount of money allocated/spent on rehabilitating/repairing the salinity exclusion structures • Number of salinity barriers designed • Number of desalination facilities established

Coastal and Marine Sector

Sri Lanka is an island nation surrounded by a low-lying coastal belt. Around a third of the country's population is concentrated in the costal belt. There are several townships located in the coastal zone and relatively well developed infrastructure facilities are found in those areas. Fisheries and tourism are among the significant economic activities in the coastal zone and numerous fishing villages, harbours and anchorages are located around the country. Nearly a quarter of a million families make their living on coastal and offshore fishing. The coastal belt is rich with numerous coastal and marine ecosystems. Beyond the beach zone, fertile strips of rice and coconut lands are located that support the food security and export earnings of the country. Overall, coastal areas contribute the country's economy significantly and a large share of population is dependent on them. Sea level rise, a major physical effect associated with climate change, is likely to create significant impacts over the coastal zone. Tsunami in 2004 has indicated that Sri Lanka's low-lying coastal areas will be highly vulnerable to inundation. Besides, rising incidence of extreme and unpredictable weather events have created uncertainties over costal livelihoods sometimes even causing life and property damages. Hence, adaptation in coastal and marine sectors is critical for the country's sustainable development.

Table 8: Sector Action Plan – Coastal and Marine Sector

Adaptation needs	Adaptation options	Actions	Responsible agencies	Key performance indicators
Strengthen the coastal zone management to face the impacts of sea level rise	A. Initiating research studies to assess impacts of sea level rise	• Study impacts of sea level rise on coastal habitats over short-medium- and long-term horizons • Study erosion trends and identify appropriate protection measures • Conduct research studies on coastal water quality and hydrodynamics in relation to climate change • Establish regional collaborations on research and monitoring	**NARA** **CC&CRMD** *MEPA* *DFAR* *EFoU/SFoU*	• Number of studies completed/published • Amount of money allocated/spent on research studies • Number of regional collaborative studies undertaken/completed/published • Number of collaborative workshop conducted • Amount of money allocated/spent on regional collaborative studies
	B. Establishment of a sea level rise monitoring system	• Identify critical shore line parameters for regular monitoring • Implement continuous monitoring of shore line changes • Prepare maps on low-lying areas vulnerable to inundation • Prepare a data base on existing coastal habitats • Promote participation of coastal communities in monitoring sea level rise • Establish the mean sea level	**CC&CRMD** **NARA** *SD*	• Number of parameters identified • Regular (Quarterly) monitoring reports produced on shore line changes • Number of area maps developed/produced on inundation • A fully functioning data base is created • Number of participants from coastal communities who are enlisted

	C. Strengthening the coastal protection and management	• Develop shoreline management plan including M & E programme • Update CZMP to ensure greater concern over climate change impacts • Prepare SMA plans to vulnerable areas • Revise set back limits considering the sea level rise • Undertake physical protection measures in critical areas – Establish green belts and increase vegetation covers – Undertake sand nourishment – Build coastal defense structures in strategic locations (**Focus**: off-shore breaks, revetment, sea walls, break waters etc.)	**CC&CRMD**	• Number of shoreline management plans developed • CZMP is updated to ensure greater concern over climate change impacts • Number of vulnerable areas with completed SAM plants • % of the shoreline areas with established set back limits to take account of sea level rise • % shoreline with established of physical protection measures
	D. Participatory management of sensitive coastal habitats	• Conduct awareness programmes on sea level rise and extreme events to coastal communities to empower them for facing climate change impacts • Prepare and implement participatory management plans for the conservation and rehabilitation of sensitive coastal habitats with the collaboration of local communities and CSOs – Conservation of mangrove, salt marshes and sea grass beds – Sand dune rehabilitation – Restoration of mangroves – Restoration of coral reefs	**CC&CRMD** *NARA* *MEPA* *DWLC* *FD*	• Number of awareness programmes conducted on sea level rise to coastal communities • Number of coastal communities with fully developed participatory management plans for the conservation and rehabilitation of sensitive coastal habitats

Enhance the resilience of coastal systems against increased extreme events	A. Improvement of disaster risk preparedness and management	• Identify and declare vulnerable coastal areas to extreme events • Collect information and prepare maps on vulnerable areas to extreme events • Prepare emergency response/contingency plans and guidelines for vulnerable areas • Establish physical protection measures in critical areas – Establish green belts and increase vegetation covers	**CC&CRMD** **DMC** *NARA*	• Number of coastal areas identified that are vulnerable to extreme events • Number of vulnerable coastal areas where data collection has completed • Number of coastal areas where completed vulnerability maps are developed • Number of vulnerable coastal areas with completed emergency response/contingency plans • % of identified vulnerable shore line areas with completed physical protection measures

Health

Health is another area that climate change can create significant impacts. Studies around the world have suggested the possibility of increased health hazards with changing climate patterns. Life cycles of biological agents associated with diseases are highly sensitive to weather and climate related parameters. On the other hand, several countries have reported a rising number of fatalities due to heat waves and disasters. Sri Lanka has reported relatively high achievements in the health sector compared with other developing nations. In spite of that, the country has recently experienced outbreak of diseases that are closely connected with environment and weather patterns. Seasonal outbreaks of dengue are a prime example of this. Spread of vector borne diseases into new areas with changing patterns of local climate is a potential health hazard that needs close attention. Sri Lanka has a history of such epidemics in the past such as periodic outbreaks of malaria. In addition, extreme weather conditions can lead to disasters causing injuries and fatalities. Besides, living and health comfort can directly be affected by gradual rise in temperature and sudden, uncharacteristic and extreme changes in weather parameters. Demographic information suggests that Sri Lanka has an ageing population which would particularly be vulnerable to climate related health hazards. Hence, serious effort towards adaptation against potential health hazards associated with climate change is a priority.

Table 9: Sector Action Plan – Health

Adaptation needs	Adaptation options	Actions	Responsible agencies	Key performance indicators
Assess and prepare for the increased health risks due to climate-induced vector bone and pathogenic diseases	A. Conducting research studies to assess the risk of climate-induced diseases	• Conduct research studies on impact of climate change on prevalence and spread of – Vector bone diseases – Pathogenic diseases • Assess critical factors for controlling climate-induced disease incidents • Identify plausible strategies for management of climate-induced disease incidents	**MOH** *MRI* *NSF* *NRC* *MFoU/SFoU*	• Number of research studies conducted • Amount of money allocated/utilized for doing research • Assessment on the critical factors for controlling climate-induced disease incidents finalized • Number of plausible strategies identified for management of climate-induced disease incidents
	B. Strengthening the surveillance and monitoring of climate-induced diseases	• Establish a surveillance program for detection and monitoring of climate-induced diseases • Prepare vulnerability maps on climate related health hazards • Establish a mechanism for sharing meteorological , clinical and entomological information (**Focus**: central and provincial data)	**MOH** *MRI*	• Surveillance programme established • Number of vulnerability maps produced • Money allocated for establishing a mechanism for sharing meteorological , clinical and entomological information
	C. Capacity development for managing climate-induced disease incidents	• Strengthen the alertness of health system against climate-induced disease incidents • Launch an awareness programme on climate and health risks for – Healthcare workers – Public • Develop/review guidelines for management of climate-induced disease incidents • Develop research institutes' capacity for conducting research on climate and health issues including multidisciplinary collaborative research	**MOH** *MRI* *NSF* *NRC* *MFoU/SFoU*	• Amount of money allocated/spent for Strengthening the alertness of health system against climate-induced disease incidents • Number of awareness programme conducted • Guidelines are developed and published • Amount of money allocated for the development • Number of training programme conducted • Amount of money spent on purchasing laboratory equipment

Minimize the health hazards associated with increased incidence of extreme events	A. Establishing an efficient climate information and communication system	• Strengthen early warning systems of extreme events • Strengthen the mechanism for sharing information between disaster management and health management agencies	**DMC** *DM* *MOH* *MRI*	• Amount of money allocated/spent on the activities on the early warning system • Number of activities initiated to strengthen the early warning system • Amount of money allocated/spent on establishment of the mechanism • Number of information sharing workshops conducted
	B. Improvement of disaster risk preparedness of health related agencies and workers	• Develop disaster risk preparedness guidelines for health workers in vulnerable areas • Increase the knowledge and awareness on health impacts of extreme events among healthcare workers (e.g. MOH, PHI) • Improve the coordination between disaster management and health management agencies	**DMC** *DM* *MOH* *MRI*	• Guidelines are developed and published • Number of awareness workshops conducted • Amount of money allocated/spent on awareness workshops • Amount of money allocated/spent on activities to strengthen the coordination • Number of coordination meetings/workshops between the agencies
Assess and prepare for health risks caused by concentration of climate altering pollutants	A. Conducting research studies to assess health impacts of climate altering pollutants	• Conduct research studies on health impacts of climate altering pollutants (**Focus**: availability, temporal variation and health impacts) • Identify and assess treatment procedures and diagnostic tools	**MOH** *MRI* *NSF* *NRC* *MFoU/SFoU*	• Number of research studies conducted • Amount of money allocated/spent on research • Number of treatment procedures and diagnostic tools identified
	B. Improvement of monitoring of climate altering pollutants	• Establish air quality monitoring facilities in strategic locations • Establish pollution dispersion and transport forecasting system (**Focus**: computer numerical modelling) • Review and improve monitoring standards of pollutants to keep up with world standards • Establish a mechanism for consulting health sector on matters concerning EPLs	**CEA** *MOH* *MRI* *NSF* *NRC* *MFoU/SFoU*	• Amount of money allocated/spent on establishing air quality monitoring facilities in strategic locations • Amount of money spent on establishment of pollution-free transport system • Number of locations where the monitoring systems are established • Amount of money allocated/spent on establishing mechanisms

	C. Capacity development for managing health impacts of climate altering pollutants	• Strengthen respiratory disease control programme • Develop guidelines for controlling exposure • Increase public awareness on health impacts of pollution • Develop a mechanism for dissemination of air pollution levels to the general public in high risk areas • Train health workers on environmental health and safety	**MOH** *MRI* *CEA*	• Amount of money allocated/spent on strengthening the programme • Guidelines are developed • Number of awareness programmes conducted • Number of training programmes conducted
Assess the impact on health due to increased heat and thermal stress	A. Conducting research studies to assess health impacts of heat/thermal stress	• Conduct research studies on heat/thermal stress on human health • Identify and assess – Diagnostic tools and treatment procedures • Increase public awareness on health risks of heat /thermal stress	**MOH** *MRI* *NSF* *NRC* *MFoU/SFoU*	• Number of research studies conducted • Amount of money allocated/spent on research studies • Assessments on the diagnostic tools and treatment procedures are completed • Number of awareness programmes conducted • Amount of money allocated/spent on awareness activities

Human Settlements and Infrastructure

Human settlements and infrastructure are two closely connected areas that come under the direct influence of climate change impacts. In Sri Lanka, they are likely to be impacted by several physical effects associated with climate change. Impacts on settlements and infrastructure have direct repercussions on basic living standards of the population. Broadly, human settlements and infrastructure in the country can be divided into three categories—urban, rural and estate. Types of impacts faced by these categories of settlements and infrastructure vary from each other and current levels of development of these three categories also are different. However, they share some common features that need the support of planned adaptation measures. Climate proof settlements and infrastructures have received the wide attention world over as innovative measures of adaptation to climate change. In Sri Lanka, human settlements and infrastructure are two areas that received limited attention despite their importance with connection to climate change adaptation.

Table 10: Sector Action Plan – Human Settlements and Infrastructure

Adaptation needs	Adaptation options	Actions	Responsible agencies	Key performance indicators
Enhance the resilience of human settlements and infrastructure against heat and water stress	A. Improvement and promotion of building designs for enhanced climate resilience	• Mainstream climate resilience in physical and urban planning and incorporate them for planning for development projects – Adopt green building concepts in planning – Encourage of wind corridors and open spaces – Promote planning the human settlement schemes so as to minimize the adverse effect – (and promote)on localized and regional water resources • Promote climate resilient building designs – Develop specifications, standards, guidelines, promotion of alternative building materials – Create public awareness – Provide training to industry stakeholders • Promote use of alternative materials – Identify and assess alternative materials – Assess the availability – Create public awareness – Provide training to industry stakeholders • Develop/review appropriate sector specific building standards and guidelines for urban, rural and estate sectors • Provide standardization of equipment such as A/C and refrigerators so they emit less GHG's	**UDA** **LAs** **NBRO** *NPPD* *ICTAD* *AchtFoU* *TCFoU* *PCs* *CHPB* *SLSI* *ITI*	• Number of workshops conducted in mainstreaming climate resilience in physical and urban planning • A document on contacting green building concepts are prepared and published • Number of workshops in promoting climate resilient building designs • Number of public awareness programmes conducted in promoting climate resilient building designs • Number of training workshops conducted for industry stakeholders in promoting climate resilient building designs • Number of workshops in promoting use of alternative materials • Number of public awareness programmes conducted in promoting use of alternative materials • Number of training workshop conducted for industry stakeholders in promoting use of alternative materials • A document contacting appropriate sector specific building standards for urban, rural and estate sectors are prepared and published

	B. Revision of procedures and guidelines	• Revise building approval systems s to ensure climate resilience – Expand the coverage of the guidelines to ensure climate resilience and minimize health impacts – Strengthen the enforcement and implementation through local governments	**UDA** **PCs** **LAs**	• Number of workshops conducted in revising the building approval systems s to ensure climate resilience • Number of awareness programmes conducted at the local government levels to Strengthen the enforcement and implementation through local governments
	C. Initiating research studies to assess climate impacts	• Conduct research studies on – Climate resilience building designs – Practical applications of green building concepts – Alternative materials	**NBRO** **ICTAD** **CHPB** *AchFoU* *TCFoU* *NSF* *NRC*	• Amount of money allocated/spent on research activities • Number of research activities conducted
	D. Sectoral Capacity development	• Conduct training programmes for industry stakeholders – Public officers – Builders – Construction workers – Architects – Designers – Environmental design department of Universities, Ex: University of Moratuwa	**ICTAD** *AchFoU* *TCFoU*	• Number of training programmes conducted • Amount of money allocated/spent on training programmes
Minimize the impacts on human settlements and infrastructure due to erratic	A. Enhance the capacity of infrastructure in urban settlements	• Extend the capacity of drainage and sewerage systems to avoid periodic overcrowding • Rationale use of drainage infrastructure to encourage recharging of ground water systems	**NWSDB** *UDA* *LAs* *PCs*	• Number of drainage and sewerage systems where the capacity is extended to avoid periodic overcrowding • Number of workshops conducted in rationalizing the use of drainage infrastructure to encourage recharging of ground water systems

changes in precipitation	B. Promote water safety and efficient utilization of surplus water	• Promote measures to ensure safety of domestic water for settlements – Household water treatment and safe storage through point-of-use practices – Strengthening the drinking water surveillance systems – Domestic water recycling and re-using • Promote use of rainwater harvesting systems to collect water in surplus periods to be used in the dry periods	**NWSDB** *UDA* *LAs* *PCs*	• Number of workshops conducted in promoting measures to ensure safety of domestic water for settlements • Number of workshops conducted in promoting the of rainwater harvesting systems to collect water in surplus periods to be used in the dry periods
Enhance the resilience of human settlements and infrastructure to extreme weather events	A. Promotion of disaster resilient buildings and construction	• Promote disaster resilient buildings (new constructions) – Promote NBRO prepared guidelines – Create public awareness – Provide training to industry stakeholders – Promote retrofitting of existing buildings • Promote practice of building codes including roofing standards specially in the public buildings	**NBRO** *NPPD* *UDA* *LAs* *PCs*	• Number of workshops conducted in promoting NBRO prepared guidelines for disaster resilient buildings • Number of public awareness programmes conducted in promoting disaster resilient buildings • Number of training programmes conducted for industry stakeholders for promoting disaster resilient buildings • Number of workshops conducted in promoting practice of building codes including roofing standards specially in the public buildings
	B. Improvement of disaster risk preparedness and management	• Prepare hazard preparedness plans for urban, rural and estate settlements including – hazard mapping – disaster response planning – awareness creation – early warning • Revisit existing preparedness plans for climate change • Develop and enforce zoning system based on hazard vulnerability	**DMC** *NPPD* *UDA* *NBRO*	• Number of hazard preparedness plans prepared for urban, rural and estate settlements including • Number of awareness programmes conducted in developing and enforcing enforce zoning system based on hazard vulnerability

Minimize the impacts of sea level rise on coastal settlements and infrastructure	A. Increase the resilience of coastal settlements	• Promote building standards which are specific to the coastal sector – Encourage practicing building codes and standards – Encourage use of proper materials in constructions – Make appropriate considerations in relation to impacts on winds – Create public awareness – Provide training to industry stakeholders	**CC&CRMD** *UDA* *NBRO* *DMC*	• Number of awareness workshops conducted in promoting building standards which are specific to the coastal sector • Number of training programmes provided for industry stakeholders
	B. Strengthening the monitoring of sea level rise	• Regular monitoring of sea level rise • Prepare maps on low-lying areas vulnerable to inundation • Demarcate coastal zones vulnerable to inundation • Develop guidelines for human settlements and infrastructure in vulnerable zones	**NARA** **DMC** *CC&CRMD* *NPPD* *NBRO*	• Quarterly monitoring reports are prepared on sea level rise • Number of maps prepared on low-lying areas vulnerable to inundation • Total coastal areas demarcated as vulnerable to inundation • A guideline document is prepared and published for human settlements and infrastructure in vulnerable zones

Ecosystems and Biodiversity

Sri Lanka is one among 35 biodiversity hotspots in the world. The country was endowed with truly remarkable bequest of biodiversity and ecosystems. This includes both fauna and flora resources. Furthermore, Sri Lanka's endowments cover terrestrial, aquatic as well marine ecosystems. Benefits of biodiversity and various ecosystem services for human well-being have been well recognized by numerous studies. Simultaneously, climate is a primary factor that determines the geographical distribution of ecosystems and availability of biodiversity around the world. However, anthropogenic factors have caused the degradation of biodiversity and ecosystems within a relatively short period. Just over a century, country's forest cover has reduced to a third of what it used to be. Several species have been listed under endangered or threatened categories. Process of biodiversity and ecosystem losses are already in rise due to human activities. Climate change has a potential to top up this tendency. Impacts of climate change could be multifaceted with both negative and positive impacts. For instance, current predictions about gradual spread of the intermediate zone in to dry zone areas can bring in challenges as well as opportunities. Despite the potential impacts, we know very little about what changes have already taken place or where the ensuing changes would eventually lead. Hence, biodiversity and ecosystems are areas where Sri Lanka needs special attention when it comes to adaptation to climate change.

Table 11: Sector Action Plan – Ecosystems and Biodiversity

Adaptation needs	Adaptation options	Actions	Responsible agencies	Key performance indicators
Enhance the resilience of natural and agro ecosystems against the impacts of climate change impacts	A. Initiating research studies to assess climate impacts	• Conduct research studies on climate change impacts on ecosystems and biodiversity – Modelling impacts of climate change on bio-diversity – Changing patterns of precipitation and boundary shifts of climatic zones – Causal factors of forest die-back and degradation of ecosystems – Traditional methods of biodiversity management – Life cycle studies: e.g.in the sex ratios – Ex-situ conservation .	**FD** **DWLC** **DNBG** **DNZG** *SFoU/AFoU* *DM* *IUCN* *NARA* *NSF*	• Amount of money allocated/spent on research activities • Number of research studies completed and published

B.	Extension of existing biodiversity protection interventions to cover climate change impacts	• Prepare adaptive management programmes for climate sensitive ecosystems – Identify and map ecosystems that are highly sensitive to climate impacts ('hot spots') – Demarcate the vulnerable sites – Prepare adaptive management programmes • Protect marshes/flood retention areas vulnerable to thermal stress – Identify threatened areas and map – Restrict land conversion of wet lands – Develop special management plans – Enhance the enforcement of law • Develop a comprehensive plan for mitigating wild/forest fire incidents – Identify hazard prone areas and prepare maps – Training of staff – Acquire new equipment – Increase awareness. – Formation of CBOs • Prepare recovery plans for highly threatened ecosystems are and species – Ex-situ conservation of highly threatened species – Captive breeding and propagation – Reintroduction to natural systems	**FD** **DWLC** **DNBG** **DNZG** *CC&CRMD* *NARA* *IUCN*	• Number of adaptive management programmes prepared • Amount of money allocated/spent on preparing adaptive management programmes • Number of workshops conducted in preparing the adaptive management programmes • Number of special management plans developed for protecting marshes/flood retention areas vulnerable to thermal stress • Number of threatened areas identified for protecting marshes/flood retention areas vulnerable to thermal stress • % land area restricted to conserve wetlands • Amount of money allocated/spent on enforcement activates • Number of vulnerable areas with comprehensive plan for mitigating wild fire incidents • Number of recovery plans prepared for highly threatened ecosystems are and species
C.	Strengthening the monitoring of climate impacts	• Establish a comprehensive programme to monitor climate change impacts on key natural ecosystems and biodiversity (**Focus**: GIS mapping) • Establish permanent monitoring plots for research on natural bio-diversity	**FD** **DWLC** *CC&CRMD* *NARA* *IUCN*	• A comprehensive plan is established to monitor climate change impacts on key natural ecosystems and biodiversity • Number of monitoring plots established for research on natural bio-diversity

	D.	Enhancing the participation of local communities in monitoring, conservation and management of biodiversity	• Conduct awareness programmes for local communities on impacts on climate change local biodiversity and ecosystems in vulnerable areas • Organize local CBOs for monitoring changes in local ecosystems and bio diversity • Increase the participation of local communities in adaptive management programmes – Increase employment opportunities for local communities in conservation activities	**DF** **DWLC** *CC&CRMD* *NGOs*	• Number of awareness programmes conducted for local communities on impacts on climate change local biodiversity and ecosystems in vulnerable areas • Number of workshops/meetings with CBO's to organize them for monitoring changes in local ecosystems and bio diversity • Ensure participation of local bodies • A monitoring system is established to ensure community participation in adaptive management programmes
	E.	Promotion of traditional methods of biodiversity conservation for increased resilience in agro-ecosystems	• Study and Identify traditional methods of biodiversity management in agro ecosystems • Identify and promote different agro-biodiversity models suitable for different agro-climatic zones – Dry Zone: Cascade system – Wet and intermediate zones: Kandyan home garden systems, *Owita* systems	**FD** **DWLC** **DOA** *SFoU/AFoU* *NGOs*	• Number of studies conducted and published to Identify traditional methods of biodiversity management in agro ecosystems • Number of agro-biodiversity models identified suitable for different agro-climatic zones
	F.	Sectoral Capacity development	• Develop research institutes' capacity for conducting research on climate change impacts on ecosystems and biodiversity • Strengthen the existing capacities for genetic preservation of fauna and flora.	**FD** **DWLC** **NSF** **DOA** *SFoU/AFoU* *IUCN*	• Amount of money allocated/spent on developing research institutes' capacity for conducting research on climate change impacts on ecosystems and biodiversity • Number of studies conducted on genetic preservation of fauna and flora • Amount of money allocated on purchasing technical equipment for genetic preservation of fauna and flora

Enhance the resilience of natural and agro ecosystems against extreme weather events	A. Improvement of disaster risk preparedness and management	• Strengthen the early warning systems – Identify and collect information on ecosystems and geographical locations most vulnerable to flood and drought hazards – Prepare emergency response/contingency plans and guidelines for vulnerable areas	**DMC** *DF* *DWLC*	• Money allocated/spent on activities to strengthen the early warning systems • Number of geographical areas identified that are most vulnerable to flood and drought hazards • Number of emergency response/contingency plans and guidelines prepared for vulnerable areas
Minimize the impacts of sea level rise on coastal bio-diversity and ecosystem services	A. Initiating research studies to assess climate impacts	• Conduct research studies on – sea level rise and salinity changes in coastal ecosystems – Impacts of salinity changes in coastal biodiversity and eco-system services	**NARA** **NSF** **CC&CRMD** *SFoU/AFoU* *IUCN*	• Number of research studies conducted on sea level rise and salinity changes in coastal ecosystems and - Impacts of salinity changes in coastal biodiversity and eco-system services • Amount of money allocated/spent on research studies on sea level rise and salinity changes in coastal ecosystems and - Impacts of salinity changes in coastal biodiversity and eco-system services
	B. Strengthening the monitoring of climate impacts	• Monitor regularly the development of salinity levels	**CC&CRMD** **NARA**	• Quarterly monitoring reports produced on the development of salinity levels
Assess the changes in oceanic environment and impacts on livelihoods and food security	A. Initiating research studies to assess climate impacts	• Assess changes in oceanic habitats and composition of species due to impacts of climate change on oceanic environment	**NARA** **CC&CRMD** *NSF* *SFoU/AFoU* *IUCN*	• Assessment report is finalized and published on oceanic habitats and composition of species due to impacts of climate change on oceanic environment • Quarterly monitoring reports published on essential bio-physical parameters (National monitoring programme)
	B. Strengthening the monitoring of climate impacts	• Initiate long-term monitoring of essential bio-physical parameters (National monitoring programme)		

Assess the impacts of rising atmospheric CO_2 on biomass production of natural vegetation and spread of invasive species	A. Initiating research studies to assess climate impacts	• Conduct research studies on impact of increased CO_2 on natural ecosystems and biodiversity – Biomass production – Food chains – Invasive alien species	**DF** *NSF* *SFoU/AFoU* *IUCN* *NARA*	• Number of research studies conducted on impact of increased CO_2 on natural ecosystems and biodiversity • Amount of money allocated/spent on conducting research on impact of increased CO_2 on natural ecosystems and biodiversity

Tourism and Recreation

Being a tropical island nation, Sri Lanka is an attractive destination for tourists. The protracted conflict since 1980s has discouraged the flow of tourists significantly over three decades. However, with the termination of war in 2009, arrival of tourists has increased steadily that reached new heights with further potential for development. Annual arrivals surpassed the one million mark recently and increasing steadily. Among the country's attractions are scenic and sunny beaches, cultural heritage, ecological endowments of rich biodiversity, opportunities for nature recreation (e.g. whale watching, beach surfing, wild life) as well as comfortable climate zones. Climate change can affect desirable characteristics associated with each of those attractions, simultaneously creating problems for operational undertaking of travelling and leisure activities. Besides, it can affect infrastructure facilities of tourism industry making them vulnerable to various hazards. Tourism industry, by its nature, is highly sensitive and susceptible to disturbing conditions such as disasters and violence. Hence, maintaining Sri Lanka's position as an attractive destination and ensuring efficient operation of the industry under rising incidence of climate hazards needs adopting carefully planned adaptation measures.

Table 12: Sector Action Plan – Tourism and Recreation

Adaptation needs	Adaptation options	Actions	Responsible agencies	Key performance indicators
Adjustment of tourism and recreation industry to altered conditions of the destination	A. Initiating research studies to assess climate impacts	• Conduct research studies on climate change impacts on tourism and recreation (**Focus**: nature based tourism, coastal zone) – Critical impacts of climate change on tourism and recreation – Ways to overcoming constraints on industry – Ways to harnessing opportunities	**SLTDA** *TFoU* *NSF*	• Number of research studies conducted and published on climate change impacts on tourism and recreation • Amount of money allocated/spent on climate change impacts on tourism and recreation
	B. Operational adjustments in the industry	• Diversify the tourism products to meet the changing conditions – Increase the portfolio of destinations and attractions – Embrace new tourism concepts – Identify new themes (e.g. adventure tourism) • Develop collaborative plans with key stakeholders to adjust tourism operations in different locations – Nature tourism: Wildlife Dept., Forest Dept. – Cultural tourism: Dept. Archeology • Increase the awareness of tour industry operators on climate change and its impacts – Prepare guidelines for operators and guides • Increase the climate preparedness in organizing and implementing tour operations – Identify comfort/discomfort zones – Prepare toolkits/guidelines for operators and guides	**SLTDA** **SLTPB** **TBSL** *FD* *DWLC* *CC&CRMD* *DArch* *THASL*	• Number of research/workshop conducted to identify new tourism concepts and themes • Number of collaborative plans developed to adjust tourism operations in different locations • Number of workshops conducted to developed collaborative plans developed to adjust tourism operations in different locations • Number of awareness programmes conducted to increase the awareness of tour industry operators on climate change and its impacts • Number of initiatives taken to Improve the climate preparedness element in organizing and executing tour operations • Number of tourism facilities identified in vulnerable areas (e.g. low-lying beaches; disaster prone areas) and make arrangements to improve the resilience

	C. Changing of promotional strategies	• Assess the current promotional strategies with connection to emerging scenarios of climate change (**Focus**: beach tourism, nature destinations) • Adjust the promotions to suit the different climate scenarios – Promotions according to seasonal variations in climate – Rebranding attractions to match the changing conditions – Identification of alternative destinations	**SLTDA** **SLTPB** **TBSL** *FD* *DWLC* *CC&CRMD* *DArch* *THASL*	• Assessment report on current promotional strategies with connection to emerging scenarios of climate change is published • Number of initiatives taken to Adjust the promotions to suit the different climate scenarios
Increase the preparedness of tourism and recreation operations to extreme weather conditions	A. Improvement of emergency risk preparedness and management	• Identify tourism facilities in vulnerable areas (e.g. low-lying beaches; disaster prone areas) and make arrangements to improve the resilience (**Focus**: vulnerability assessment, retrofitting, climate proofing) • Prepare guidelines on managing emergencies in tour operations • Train tour operators on emergency management strategies • Design tourism infrastructure to meet the safety needs of operations • Build system's capacity for smooth switching to alternate plans • Establish emergency communication channels for tourists and operators (**Focus**: mobile and internet based communication)	**DMC** **SLTDA** *SLTPB* *TBSL* *THASL*	• Guidelines on managing emergencies in tour operations are developed • Number of tour operators trained on emergency management strategies • Number of tourism infrastructures designed to meet the safety needs of operations • Amount of money allocated on developing system's capacity for smooth switching to alternate plans • Amount of money allocated on establishing emergency communication channels for tourists and operators
	B. Establishment of an efficient climate information management and communication system	• Develop a system for timely issuing of short-term weather forecasts • Strengthen the early warning systems (**Focus**: mobile and internet based communication)	**DM** **SLTDA** *SLTPB* *TBSL* *THASL* *DMC*	• A system is developed for timely issuing of short-term weather forecasts • Number of initiatives taken to strengthen the early warning systems

Export Agriculture Sector

All governments of Sri Lanka have been striving to achieve an export-led growth for the economy. Until the final quarter of the last century, Sri Lanka remained highly dependent over three agricultural commodities—tea, rubber and coconut—for a major share of its export earnings. Liberal economic reforms introduced in 1977 has transformed the structure of the export sector significantly, apparel industry becoming the major source of foreign earnings. Despite the reduction of relative share of agricultural exports, however, they continued to grow and still contribute a significant share of foreign earnings. Besides, three major agricultural commodities, spice crops, floriculture, aquaculture products, and non-traditional exports such as herbal products have also grown recently. Sri Lanka's economy needs the continuous support of this sector and there is significant unrealized potential yet to explore. Unlike seasonal agricultural crops that supports the country's food security, majority of export agricultural commodities are perennial in nature and concentrated in wet zone areas of the country. However, being agricultural commodities, they are also sensitive to changing patterns of weather and climate. Unlike in the past when major export commodities had been produced in large estates run by companies, current production base of agricultural commodities is dominated by small-scale producers. Hence, climate change impacts on these commodities can create significant livelihood outcomes affecting a large section of population in the country. High climate sensitivity and dependence by a large segment of small producers for their livelihoods make export agricultural sector a vulnerable area that needs special measures of adaptation to cope with impending changes of climate.

Table 13: Sector Action Plan – Export Agriculture Sector

(Focus: tea, rubber, coconut, coffee, cocoa, spices, cashew and sugarcane[1])

Adaptation needs	Adaptation options	Actions	Responsible agencies	Key performance indicators
Enhance the resilience of export agricultural crops and agro-ecosystems against heat and water stress	A. Germplasm improvement	• Screen existing cultivars/clones for heat and water stress. • Introduce new cultivars /clones – Heat tolerant – Drought tolerant – Flood tolerant • Develop grafted/budded plants with drought resistance properties	**MOPI** *TRI* *RRI* *CRI* *DEA* *SLCC* *SRI* *AFoU*	• Number of existing cultivars/clones for heat and water stress • Number of new cultivars /clones introduced • Number of grafted/budded plants developed with drought resistance properties
	B. Improvement of farm and nursery management practices	• Improve the management of shade trees as a climate change adaptation measure – Conduct nursery and field trials – Develop recommendations and guidelines • Promote suitable operational and management techniques – Application of Anti-transpirents (rubber) – Drip irrigation (with the new expansions in dry zone) – Mulching – Intercropping with spices • Develop improved cropping system models for vulnerable areas/lands • Promote improved nursery and plant management practices – New soil mixtures – Use soil quality index – Use of machinery for replanting	**MOPI** *TRI* *TBSL* *TSHDA* *RRI* *RDD* *CRI* *CDA* *CCB* *DEA* *SLCC* *SRI* *AFoU* *NIPM*	• Number of nursery and field trials conducted to Improve the management of shade trees as a climate change adaptation measure • Number of guidelines developed to Improve the management of shade trees as a climate change adaptation measure • Number of promotional workshops completed for promoting suitable operational and management techniques • Number of improved cropping system models developed for vulnerable areas/land • Number of improved nursery and plant management practices promoted • Number of promotional workshops to promote improved nursery and plant management practices

[1] Sugar cane is not an export crop in Sri Lanka. However it is managed as a plantation crop. Therefore adaptation of sugarcane is taken into consideration under this section.

			– Improvements in irrigation: nursery and new plantings – New planting techniques: root trainers – Improve soil organic matter: Bio-fertilizer development:		
	C.	Initiating research studies to assess climate impacts	• Conduct research studies on – Crop physiology: heat and drought resistance – Physiology of flowering: Synchronizing of flower irregularities – Resistance cultivars – Inter cropping: banana, cocoa, cash crops such as maize – Deep planting: at nursery and replanting levels – Cropping systems for climate resilience	**MOPI** *TRI* *RRI* *CRI* *DEA* *SLCC* *SRI* *AFoU*	• Number of research studies conducted and published • Amount of money allocated/spent on research studies
	D.	Sector capacity development	• Develop research institutes' capacity for conducting research on tolerant cultivars/clones • Develop facilities necessary to undertake controlled environment research	**MOPI** *TRI* *RRI* *CRI* *DEA* *SLCC* *SRI* *AFoU* *NSF*	• Amount of money allocated/spent on developing research institutes' capacity for conducting research on tolerant cultivars/clones • Amount of money allocated/spent on developing facilities necessary to undertake controlled environment research
Minimize the risk of crop damage due to biological agents	A.	Germplasm improvement	• Screen existing cultivars/clones for pest and disease resistance. • Develop pest and diseases resistant varieties	**MOPI** *TRI* *RRI* *CRI* *DEA* *SLCC* *SRI* *AFoU*	• Number of existing cultivars/clones screened for pest and disease resistance • Number of pest and diseases resistant varieties

	B. Improvement of farm and nursery management practices	• Develop recommendations on best practices of pest and disease management through improvements in: – Shade tree management – Nursery management – Crop sanitation	**MOPI** *TRI* *RRI* *CRI* *DEA* *SLCC* *SRI* *AFoU*	• Number of recommendations developed on best practices of pest and disease management through improvements
	C. Monitoring and surveillance of pests and diseases	• Establish a surveillance programme for early detection of new diseases and pests • Develop a system forecasting risks of pest and diseases	**MOPI** *TRI* *RRI* *CRI* *DEA* *SLCC* *SRI*	• A surveillance programme established for early detection of new diseases and pests • A system forecasting risks of pest and diseases developed
Minimize the impact on export earnings due to erratic changes in precipitation	A. Establishment of an efficient climate information management and communication system	• Develop a system for timely issuing of seasonal and short-term weather forecasts • Adjust calendar of operations with seasonal weather forecasts	**DM** *TRI* *RRI* *CRI* *DEA* *SLCC* *SRI*	• A system is developed for timely issuing of seasonal and short-term weather forecasts • A calendar of operations is adjusted with seasonal weather forecasts
	B. Improvements in cropping systems	• Promote sustainable cropping system practices for increasing the resilience of plantations and trees – Rainwater harvesting – Shade tree management – Agro-forestry and timber plantations – Cover crops – Contour drains – Land suitability assessment (e.g. 60% slope) – Soil and moisture conservation practices	**MOPI** *TRI* *TBSL* *TSHDA* *RRI* *RDD* *CRI* *CDA* *CCB* *DEA* *SLCC* *SRI* *AFoU* *NIPM*	• Number of money allocated/spent on promoting sustainable cropping system practices for increasing the resilience of plantations and trees • Number of sustainable cropping system practices promoted for increasing the resilience of plantations and trees • Number of promotional workshops conducted to promote sustainable cropping system practices for increasing the resilience of plantations and trees

Enhance the resilience of export crops and agro-ecosystems to extreme weather events	A. Establishment of an efficient climate information management and communication system	• Develop a system for timely issuing of short-term weather forecasts • Strengthen the early warning systems	**DM** *TRI* *RRI* *CRI* *DEA* *SLCC* *SRI*	• A system is developed for timely issuing of short-term weather forecasts • Money allocated/spent on strengthening the early warning systems
	B. Improvement of disaster risk preparedness and management	• Identify and collect information on areas most vulnerable to flood and drought hazards • Prepare hazard vulnerability maps for all crops • Develop guidelines for management of extreme events in vulnerable areas	**DMC** *TRI* *RRI* *CRI* *DEA* *SLCC* *SRI*	• Number of areas identified and data collected on most vulnerable to flood and drought hazards • Number of plans developed for areas that are most vulnerable to flood and drought hazards • Number of guidelines developed for areas most vulnerable to flood and drought hazards (extreme events)
Minimize the impacts of sea level rise on export crops in coastal zone	A. Strengthening the monitoring of climate impacts	• Monitor regularly the development of salinity levels	**NARA** **CC&CRMD** *CRI* *SLCC* *DEA*	• Quarterly monitoring reports on development of salinity levels are published • Number of money allocated/spent on constructing salinity exclusion structures and salinity barriers to control sea water intrusions to agricultural lands • Number of salinity exclusion structures and salinity barriers to control sea water intrusions to agricultural lands constructed
	B. Development of protection structures	• construct salinity exclusion structures and salinity barriers to control sea water intrusions to agricultural lands		

Industry, Energy and Transportation

Energy, industry and transportation are generally considered as sectors that are relevant in the case of mitigation rather than adaptation to climate change. However, stakeholders and experts suggested these sectors also need the support of certain adaptation measures to cope up with projected climate impacts. Hence, these sectors are considered here not for their contribution to mitigation of climate change but for identifying and implementing essential adaptation measures to enhance the climate resilience of them. Sri Lanka's power generation is still dependent on hydro power facilities to a significant extent and changing patterns of rainfall have would have an impact on them. Rainfall patterns are crucial for supply of raw materials for agro-based industries. Besides, rising scarcity of water and high extraction of groundwater would likely to create difficulties in industrial water supply in the future. Extreme events have the potential to affect transportation. Hence, despite usual affiliation of these sectors with mitigation efforts, they need the support of appropriately designed adaptation measures, too.

Table 14: Sector Action Plan – Industry, Energy and Transportation

Adaptation needs	Adaptation options	Actions	Responsible agencies	Key performance indicators
Minimize the impacts of rising temperature and periodic scarcity of water on energy, industry and transportation	A. System improvements and diversification of energy and power generation	• Minimize the fluctuation of hydro power generation potential through improvements in system management – Prepare and implement watershed management plans in major-hydro and mini-hydro reservoirs – Plan the generation using short-term and seasonal forecast of weather • Explore alternatives for maximizing the use of hydro power facilities: e.g. pumped-storage hydroelectricity • Improve the efficiency of transmission and distribution systems to minimize losses • Diversify the energy mix with increased share of renewable energy (**Focus**: recommendations on TNA-Energy Sector) • Factor in climate change into long-term generation plans	**CEB** **SEA** *DM* *EFoU*	• Amount of money allocated/spent on minimizing the fluctuation of hydro power generation potential through improvements in system management • Number of alternatives for maximizing the use of hydro facilities: e.g. pump storage explored and identified • Number of workshops conducted on improving the efficiency of transmission and distribution systems to minimize losses, diversifying the energy mix with increased share of renewable energy (TNA recommendations) and factoring climate change into long-term generation plans
	B. Supply chain improvements in agro-based raw materials	• Diversify the supply sources: – Identify climate sensitive raw materials – Assess the specific vulnerabilities – Promote the production in wider range of locations • Develop forward contract markets for agro-based raw materials • Introduce innovative risk transfer instruments	**IDB** *ITI* *DOA* *NCPC*	• Number of workshops conducted on identifying climate sensitive raw materials, assessing the specific vulnerabilities and promoting the production in wider range of locations • Number of forward contracts developed for markets for agro-based raw materials • Number of innovative risk transfer instruments introduced

	C. Initiating research studies to assess climate change impacts	• Conduct research studies on impacts of climate change on energy, transportation and industry – Explore and assess the potential for establishing pumped-storage hydroelectricity (PSH) plants and conversion/ retrofitting of existing facilities to PSH plants – Identify climate sensitive agro-based raw materials and assess alternatives to ensure stable supply – Assess the impacts of climate change impacts on transport systems and road infrastructure	**CEB** **SEA** **ITI** **NERD** **RDA** *EFoU*	• An assessment report on the potential for developing (and retrofitting) pumped-storage hydroelectricity facilities is completed and published • Number of research studies conducted
Minimize the impacts of extreme weather events on energy, industry and transportation	A. Improvement of the climate resilience and disaster risk preparedness of transportation	• Assess the impacts of projected changes and extreme weather scenarios on transportation systems • Assess vulnerable and hazard prone areas/roads and prepare maps • Identification of climate resilient improvements in – Transport planning – Infrastructure development – Implementation of plans • Develop guidelines for improve the resilience of transportation system for extreme weather situations • Create awareness on climate risks in transportation to commuters, drivers and transport operators • Establish an early warning and hazard communication systems for commuters and drivers (**Focus**: mobile phones, navigation systems, radio channels)	**DMC** **MOT** *DMT* *SLR* *SLTB* *RPTAs (PC)* *RDA*	• An assessment report on the impacts of projected changes and extreme weather scenarios on transportation systems I completed and published • Number of areas with hazard prone areas/roads maps • A guideline report to improve the resilience of transportation system for extreme weather situations is completed and published • Number of awareness programmes conducted on climate risks in transportation to commuters, drivers and transport operators • An early warning and hazard communication system is established for commuters and drivers

	B. Development of climate resilient infrastructure and production facilities	• Promote climate proof infrastructure and building design practices – identify design improvements for transport, energy and industry sector – Develop guidelines – Create awareness among planners, builders and operators of facilities – Develop and conduct training programs • Assess suitable interventions to strengthen climate resilience of energy sector and industrial facilities to extreme events – Introduce 'climate proofing' improvements – Retrofitting – Relocation of facilitates (if necessary)	**NBRO** **NERD** **ITI** *EFoU/AFoU*	• Number of awareness programmes on promoting climate proof infrastructure and building design practices • Guideline report on promoting climate proof infrastructure and building design practices is prepared and published • Number of critically vulnerable energy and industrial facilities in hazard prone areas identified • An assessment report on suitable interventions to strengthen climate resilience is prepared and published
	C. Improvement of disaster risk preparedness and management	• Identify vulnerable areas for climate-induced disaster risks on energy, transportation and industrial facilities and prepare maps • Develop a system for timely issuing of short-term weather forecasts • Establish an early warning system of disasters to energy, transport and industry managers	**DMC** **DM**	• Number of vulnerable areas identified and maps prepared for climate-induced disaster risks • A system is developed for timely issuing of short-term weather forecasts • An early warning system is established for energy, transportation and industrial managers
Minimize the impacts of sea level rise on energy, transportation and industrial facilities	A. Strengthening the monitoring of sea level rise	• Regular monitoring of sea level rise • Prepare maps on low-lying areas vulnerable to inundation • Demarcate coastal zones vulnerable to inundation • Develop guidelines for economic activities in vulnerable areas	**CC&CRMD** **NARA**	• Quarterly monitoring reports on of sea level rise is prepared and published • Number of maps prepared on low-lying areas vulnerable to inundation • Total coastal areas demarcated with vulnerability to inundation • Guideline are prepared for economic activities in vulnerable zones and published

	B. Increase the preparedness for sea level rise	• Identify critically vulnerable energy, transportation and industrial facilities in vulnerable areas to inundation • Develop contingency plans to gradual relocation and development of alternatives	**MOI** **MOE** **MOT** *DMC* *CC&CRMD*	• Number of critically vulnerable energy, transportation and industrial facilities in vulnerable zones to inundation identified • Number of contingency plans developed to gradual relocation and development of alternatives
	C. Initiating research studies to assess climate change impacts	• Conduct research studies on impact of climate change on industries located in coastal areas (**Focus**: salt, coir and coconut-based industries, mineral sands, boat building industries) • Identify adaptation actions suitable for respective industries	**MOI** *ITI* *IDB* *NERD*	• Number of research studies conducted to assess the vulnerability of industries based on coastal areas • Number of adaptation actions identified that are suitable for respective industries

7.6. Plan for Cross-cutting National Needs of Adaptation

Action plan for cross-cutting needs contain actions/interventions proposed to fulfill adaptation needs of ten interest areas. These areas were identified through analysis of common sectoral needs and opinions of stakeholders. The actions of cross-cutting plan have been selected to fulfil national level adaptation needs. Action plan on cross-cutting adaptation needs begin with specific interest areas followed by details on actions, responsible agencies and key performance indicators. The specific institutional and implementation mechanisms proposed for implementation of cross-cutting plan are presented in forthcoming sections of the plan. Table 15 presents the action plans for cross-cutting adaptation needs.

Table 15: Action Plan – Cross-cutting Needs of Adaptation

Cross cutting area	Action	Responsibility	Key performance indicators
Policy, legal economics and governance	Undertake a review of relevant macro and sectoral policies, ordinances, acts, statutes and procedures to identify options for mainstreaming climate change adaptation activities in Sri Lanka	**MOEnv** *CCS*	• A review report is prepared and published on relevant macro and sectoral policies, acts and procedures to identify options for mainstreaming climate change adaptation activities in Sri Lanka
	Develop policy recommendations necessary for addressing vulnerability to impacts of climate change in all development /management projects in terms of : • Assessing the climate vulnerability and sensitivity of projects (climate impact assessment); • Ensuring the inclusion of adaptive responses to overcomer climate vulnerabilities; • Implementation and monitoring of proposed adaptive actions	**MOEnv** *CCS*	• Number of policy recommendation developed for ensuring climate vulnerability issues are addressed in all development /management projects • An assessment report on the the climate vulnerability and sensitivity of projects (climate impact assessment) is prepared and published
	Carry out a policy study to explore the possibilities for: • Application of market-based instruments to motivate adaptive actions • Assessing feasibility of introducing innovative risk transfer tools (**Focus**: climate insurance schemes)	**MOEnv** *CCS*	• A policy study is finished and published to explore the possibilities for application of market-based instruments to motivate adaptive actions and identify and assess feasibility of introducing innovative risk transfer tools (e.g. index insurance schemes)
Institutional and coordination	Restructure and strengthen the Climate Change Secretariat as the National Focal Point (NFP) for implementation of NAP: • Increase the strength of staff • Provide training for professional staff • Provide necessary capacity building support for NAP implementation • Allocate sufficient budgetary provisions	**MOEnv** **MOF** *CCS*	• Number of staff increased • Number of training provided for professional staff • Number of capacity building workshops conducted • Amount of money allocated to restructure and strengthen the Climate Change Secretariat as the National Focal Point (NFP) for implementation of NAP

	Establish a suitable institutional mechanism for implementation of sectoral and cross-cutting actions of NAP. • *Climate Adaptation Cells (CAC)* for implementation of sectoral adaptation plans. To be represented by relevant sectoral agencies • *National Working Group (NWG)* for implementation of cross-cutting adaptation interventions. To be represented by national lead agencies • *Provincial Adaptation Cells (PAC)* for implementation of actions to be undertaken in provincial areas. To be represented by provincial agencies		• Climate action cells are established for implementation of sectoral adaptation plans. To be represented by relevant sectoral agencies • National Working Group (NWG) is established for implementation of cross-cutting adaptation interventions. To be represented by national lead agencies
	Organize a *Forum of Civil Society Organizations* (FCSO), a group of partner agencies, to support the implementation and coordination of community-based sectoral and cross-cutting interventions proposed by NAP	**MOEnv** *CCS*	• A Forum of Civil Society Organizations (FCSO) is organized
International cooperation and partnerships	Develop an inventory of international climate donors, funding schemes, training providers, training programmes, research agencies/consortiums and events (conferences, seminars etc.) for the benefit of local stakeholders of adaptation.	**CCS** *MOFA* *ERD*	• An inventory of international climate donors, funding schemes, training providers, training programmes, research agencies/consortiums and events (conferences, seminars etc.) is developed
	Establish a network of sectoral and national agencies, CSO partners, research institutes, think tanks and academics to approach international service providers through the facilitation support of the National Focal Point for funding support, technical assistance or training necessary for adaptation actions identified in NAP or supportive programmes developed to achieve the NAP objectives	**MOEnv** *CCS* *NSF* *CSOs*	• A network of sectoral and national agencies, CSO partners, research institutes, think tanks and academics is established
	Identify a group of sectoral and national level representatives from government organizations, CSOs and private sector to create a pool of climate negotiators • Develop the negotiation skills through training • Establish a facilitative mechanism for enlisting their services according to the requirement s through the National Focal Point	**MOEnv** **MOFA** *CCS* *SLIDA*	• Number of training programme conducted in developing the negotiation skills • A facilitative mechanism is established for enlisting services of trained negotiators according to the requirement s of the NAP programs

Resource mobilization	Create a *National Adaptation Fund* with the collaboration of the Ministry of Finance to support the implementation of NAP actions and supportive programmes	**MOF** **MOEnv** *CCS*	• A National Adaptation Fund is created • Amount of money allocated • Number activities/programmes funded
	Develop a 'fast track' mechanism for approving requests for donor funding for climate adaptation projects through the collaboration of the National Focal Point and the External Resources Department	**MOF** **MOEnv** *CCS* *ERD*	• A fast track mechanism is developed for approving requests for donor funding for climate adaptation projects
	Negotiate and establish a state-private partnership trust fund for attracting and channeling corporate social responsibility (CSR) funding for climate adaptation projects with the support of the Finance Ministry and corporate sector members	**MOF** **MOEnv** *CCS* *NCC* *FCCISL*	• A partnership trust fund with the corporate sector for channeling CSR funding for climate adaptation projects is negotiated and established
Research and development	Establish national level controlled environment research facilities in selected institutes for facilitation of multi-disciplinary research	**NSF** *NRC*	• Number of national level controlled environment research facilities established • Amount of money allocated for controlled environment research
	Establish a national network of research agencies and universities that are carrying out research on climate adaptation for promoting coordinated research and information dissemination	**NSF** *NRC* *CARP*	• A national network of research agencies and individual researchers on climate adaptation is established
	Organize an annual multi-disciplinary research symposium on climate change adaptation with international participation.	**CCS** **NSF**	• Number of annual multi-disciplinary research symposiums on climate change adaptation with international participation are conducted
	Develop a coordinated multi-disciplinary small research grant programme on thematic areas relating to climate change adaptation to be facilitated by the National Focal Point and managed by the national research support agencies (e.g. NSF, NRC, CARP)	**CCS** **NSF** *CARP* *NRC*	• A coordinated multi-disciplinary small research grant programme is developed
	Undertake advanced multidisciplinary studies on selected core areas of nationally important climate change adaptation issues supported by national and international donor funding (**Focu**s: germplasm improvement; climate modelling; stress physiology; climate information products)	**NSF** *NRC* *CCS*	• A funding facility for advanced studies on selected core areas of nationally important research is created
	Establish a common repository of scientific and awareness materials on climate change adaptation	**CCS** *NSF*	• A common repository of scientific and awareness materials on climate change adaptation is established

Technology transfer and standards	Identify international technology transfer service providers and technology developers and negotiate with them to establish technology and skills transfer opportunities for local researchers, trainers, experts, technology users and students	**CCS**	• Number of international technology transfer service providers and technology developers identified • Number of negotiations completed
	Organize national level technology transfer events and programmes (e.g. dissemination programmes, exhibitions, training programmes and demonstrations) to transfer technology/knowledge from developers and experts to technology users	**CCS** **NSF**	• Number of national level technology transfer events and programmes organized
Building adaptive capacity of communities	Develop a small grant facility jointly coordinated by *CSO Forum* and the National Focal Point to provide seed funding for community-based adaptation programmes to be financed through the *National Climate Adaptation Fund*	**CCS** *CSOs*	• A small grant facility to provide seed funding for community-based programmes helpful for achieving NAP objectives is developed
	Launch a partnership programme of academics, CSO members and researchers for gathering, compiling, documentation and analyzing of traditional local knowledge systems on climate and indigenous forecasting to be used in developing participatory community-based adaptation programmes.	**CCS** *CSOs* *AFoU*	• A programme for gathering, compiling and documentation of traditional local knowledge is completed
	Initiate a joint island wide programme for identification of religious, cultural and archaeological assets vulnerable to climate change impacts with the participation of experts (on archaeology, culture, religious affairs), CSO members and local communities for conservation of threatened assets.	**MOCA** *DOArch* *PGIArch* *DCA* *ROs* *CSOs*	• An island wide program is initiated for identification and vulnerability assessment of religious, cultural and archaeological assets threatened by climate change
Education, training and awareness	Conduct training programmes for government officers, CSO members, and private sector employees on climate change adaptation	**CCS** *AFoU* SLIDA	• Number of training programmes developed and conducted for government officers, CSO members, and private sector employees on climate change adaptation
	Incorporate and further strengthen climate change knowledge in formal education–school and university curricula	**CCS** **MOE** DE NIE UGC	• An assessment report on the current contents of school and university curricula to improve them further is completed and published

	Establish a media space including social media for climate change impacts and adaptation to enhance public awareness	**MOEnv** **MOMMI** CSOs	• A media space is created for climate change adaptation to enhance public awareness • Number of awareness initiatives taken by the established media space
Climate information management	Establish a *National Task Force on Climate Information Products* to strengthen current efforts for developing seasonal and sub-season climate forecasts: • Identify climate and weather forecast needs of different stakeholders • Identify a set of essential short-term and seasonal weather forecasting products • Launch a national programme for producing selected weather forecasting products with international technical support • Identify a suitable communication strategy for ensuring timely reach of information to end users and implement it	**DM** *CCS* *DMC* *DOA*	• A National Task Force on Climate Information Products to strengthen current efforts for developing weather forecasts is organized • Number of workshops conducted in identifying climate and weather forecast needs of different stakeholders and set of essential short-term and seasonal weather forecasting products • A national programme is launched for producing selected weather forecasting products with international technical support • A suitable communication strategy for ensuring timely reach of information to end users is identified and implemented
	Identify capacity development needs of the Department of Meteorology and provide necessary support to strengthen the capacity for offering reliable weather and seasonal and sub-season climate forecasts. • Increase the strength of staff • Provide training for professional staff • Provide necessary capacity building support for NAP implementation • Strengthen the network of meteorological data collection centres • Allocate sufficient budgetary provisions	**DM** *MOF*	• Number of staff increased and number of training programmes conducted for professional staff. • Number money allocated/spent on capacity building support for NAP implementation and strengthening the network of meteorological data collection centres
	Undertake a study on indigenous short- and medium-range weather forecasting knowledge and identify ways to incorporate it into a national climate risk surveillance programme. • Explore the modalities developed in other countries • Recruit trained local weather observers	**DM** *CCS* *DOA* *AFoU/SFoU/EFoU* *NSF*	• A study is undertaken and completed on indigenous weather forecasting knowledge and ways are identified to incorporate it into a national climate risk surveillance programme

	Establish a national research programme on climate modelling for long-term climate projections	**DM** **DOA** AFoU/SFoU/EFoU NSF NRC	• A national research programme is established on climate modelling for long-term projections • Number of research studies conducted and published under the established research programme
Climate-induced disaster risk reduction	Assess the disaster risk reduction needs of sectoral Climate Adaptation Cells (identified in NAP) and mainstream the implementation of them with ongoing programmes of disaster risk management	**MODM** **DMC** CCS	• A coordination committee is established • An assessment report is prepared and published by the established committee on disaster risk needs of sectoral Climate Adaptation Cells

8. Adaptation and Sustainable Development: The Potential Contribution of NAP towards Achieving SDGs

Since the official adoption by the UN in 2015, Sustainable Development Goals (SDGs) are going to play a dominant role in the global development agenda till 2030. All UN member nations are expected to make their contributions towards achieving the global development scenario envisioned by SDGs to the extent they are relevant to their national development goals. In practical sense, this would have important repercussions on many areas such as development planning and policy, poverty alleviation, environmental management, trade and international development cooperation. Hence, it is necessary to assume the primacy of SDGs in the global agenda by practitioners of development in all areas and climate change is not an exception. In the final count, adaptation is all about adjusting the discourse of development in the face of rising climate risk and it does not possess significant meaning without its contribution to the sustainable development. This implies that the NAP should assist the nation to achieve the broader goals of SDGs and vice versa. The SDGs have 17 goals and 169 targets of which Goal Number 13 is fully dedicated to climate change with 9 targets associated with it. In addition, number of other goals covers areas relevant to climate change adaptation with relevant targets attached to them. The NAP is essentially contributing to number of SDGs and how the specific goals are addressed by the relevant adaptation options and actions are shown in Table 16.

Table 16: Links between SDGs and NAP

SDG Goal and Target	Sector in NAP	Adaptation need	Adaptation Action
Goal 1: End poverty in all its forms everywhere			
1.5 by 2030 build the resilience of the poor and those in vulnerable situations, and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	Coastal sector	Enhance the resilience of coastal ecosystems against increased extreme events	▪ Improvement of disaster risk preparedness and management
	Cross cutting needs of adaptation	Climate-induced disaster risk reduction	▪ Assess the disaster risk reduction needs ▪ Mainstream the implementation with ongoing programs of disaster risk management
Goal 2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture			
2.4 by 2030 ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that progressively improve land and soil quality	Food security	Enhance the resilience of crops, animals, fish and agro-ecosystems against heat and water stress	▪ Germ plasm improvements ▪ Improvement of farm water management ▪ Promotion of resource efficient farming systems ▪ Sectoral Capacity development
		Minimize the risk of crop and health damage due to biological agents	▪ Germ plasm improvements, ▪ Strengthening of supporting facilities,
		Minimize the impact on food security due to erratic changes in precipitation	▪ Establishment of an efficient climate information management and communication system, ▪ Improvement of pasture and fodder management
		Enhance the resilience of crops, animals, fish and agro-ecosystems to extreme weather events	▪ Germ plasm improvements ▪ Improvement of disaster risk preparedness and management

		Minimize the impacts of sea level rise on agriculture in coastal zone	▪ Germ plasm improvements ▪ Strengthening the monitoring of climate impacts
		Assess the changes in oceanic environment and impacts on livelihoods and food security	▪ Initiating research studies to assess climate impacts Strengthening the monitoring of climate impacts
		Assess the impacts of rising atmospheric CO_2 on productivity crops and weed populations	▪ Initiating research studies to assess climate impacts
Goal 3: Ensure healthy lives and promote well-being for all at all ages			
3.d strengthen the capacity of all countries, particularly developing countries, for early warning, risk reduction, and management of national and global health risks	Health	Assess and prepare for the increased health risks due to climate-induced vector bone and pathogenic diseases	▪ Conducting relevant research studies ▪ Strengthening the surveillance and monitoring ▪ Capacity development
		Minimize the health hazards associated with increased incidence of extreme events	▪ Improvement of disaster risk preparedness of health related agencies and workers
		Assess and prepare for health risks caused by concentration of climate altering pollutants	▪ Conducting relevant research studies • Improvement of monitoring of climate altering pollutants and capacity development
		Assess the impact on health due to increased heat and thermal stress	▪ Conducting relevant research studies
Goal 6: Ensure availability and sustainable management of water and sanitation for all			
6.4 by 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water	Water resources	Enhance the resilience of systems for water resources, management and use to overcome the scarcities caused by climate change impacts	▪ Improvement of watershed management ▪ Capacity development ▪ Promote efficient practices of water management and use

scarcity, and substantially reduce the number of people suffering from water scarcity **6.6** by 2020 protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes		Ensure the safety of water management facilities and minimize disturbances to supply due to extreme weather events	▪ Improvement of disaster risk preparedness and management ▪ Capacity development of storage facilities
		Minimize the impacts of sea level rise on water resources and management of coastal areas and wet lands	▪ Strengthening the monitoring of sea level rise, ▪ Improve salt water intrusion protection measures in coastal areas and wetland
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable			
11.5 by 2030 significantly reduce the number of deaths and the number of affected people and decrease by y% the economic losses relative to GDP caused by disasters, including water-related disasters, with the focus on protecting the poor and people in vulnerable situations	Human settlements	Minimize the impacts on human settlements and infrastructure due to erratic changes in precipitation	Enhance the capacity of infrastructure in urban settlements, Promote water safety and efficient utilization of surplus water
11.b by 2020, increase by x% the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, develop and implement in line with the forthcoming Hyogo Framework holistic disaster risk management at all levels		Enhance the resilience of human settlements and infrastructure to extreme weather events Minimize the impacts of sea level rise on coastal settlements and infrastructure	Promotion of disaster resilient buildings and construction, Improvement of disaster risk preparedness and management Increase the resilience of coastal settlements, Strengthening the monitoring of sea level rise
Goal 13: Take urgent action to combat climate change and its impacts			

13.1 strengthen resilience and adaptive capacity to climate related hazards and natural disasters in all countries	Cross-cutting needs of adaptation	Building adaptive capacity of communities	▪ Develop a small grant facility ▪ Initiatives to promote traditional local knowledge on climate adaptation
13.2 integrate climate change measures into national policies, strategies, and planning	Cross-cutting needs of adaptation	Policy, legal and governance	▪ Identification of options for mainstreaming climate change adaptation ▪ Policy study on market-based instruments ▪ Promote suitable risk transfer tools
13.3 improve education, awareness raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction, and early warning	Cross-cutting needs of adaptation	Education, training and awareness	▪ Conduct training programs for stakeholders ▪ Incorporate and further strengthen climate change knowledge in formal education, ▪ Establish a media space for climate change impacts and adaptation
Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development			
14.3 minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	Coastal and marine sector	Strengthen the coastal zone management to face the impacts of sea level rise	▪ Initiating relevant research studies
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss			
15.3 by 2020, combat desertification, and restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land-degradation neutral world	Ecosystems and Biodiversity	Enhance the resilience of natural and agro ecosystems against the impacts of climate change impacts	▪ Extend the existing biodiversity protection interventions to cover climate change impacts, ▪ Enhance the participation of local communities ▪ Research and Sectoral Capacity development

		Enhance the resilience of natural and agro ecosystems against extreme weather events	▪ Improvement of disaster risk preparedness and management
15.5 take urgent and significant action to reduce degradation of natural habitat, halt the loss of biodiversity, and by 2020 protect and prevent the extinction of threatened species		Minimize the impacts of sea level rise on coastal bio-diversity and ecosystem services	▪ Initiating research studies to assess climate impacts, Strengthening the monitoring of climate impacts
		Assess the changes in oceanic environment and impacts on livelihoods and food security	▪ Initiating research studies to assess climate impacts, Strengthening the monitoring of climate impact

9. Institutional and Coordination Mechanism

Given the comprehensive nature of the plan, it should be coordinated properly at both levels of implementation, namely, sector level and national level. Therefore, a suitable institutional and coordination mechanism is an indispensable component of the plan. Essential elements of the coordination mechanism are:

- National Focal Point
- Climate Adaptation Cells for Sectors
- National Working Group for Cross-cutting National Adaptation Needs
- CSO Forum

9.1. National Focal Point (NFP)

The National Focal Point (NFP) takes the responsibility of overall coordination of the plan. According to the current institutional set-up, CCS is the most suitable agency to undertake this task. It is necessary to strengthen the capacity of CCS through providing necessary resources and enhancing its staff skills through training.

9.2. Sectoral Climate Cells (SCC) for Sectors

Sectoral Climate Cells (SCC) will be established for vulnerable sectors to coordinate activities within respective sectors. It shall be represented by members of state agencies, private sector, community organizations and NGOs who are key stakeholders of a given sector. For instance, climate cell of the coastal sector should be represented by state agencies such as Coastal Conservation Department, Fisheries Department, NARA and private, community and non-government organizations involved in the coastal sector. Climate cell of a given sector/area should coordinate all activities pertaining to implementation and monitoring of activities of that entity.

Nine vulnerable sectors shall be organized under six SCCs as follows.

1. Climate Cell 1: Food security and water
2. Climate Cell 2: Bio-diversity and coastal resources
3. Climate Cell 3: Health
4. Climate Cell 4: Human settlements and infrastructure
5. Climate Cell 5: Tourism, energy, industry and infrastructure
6. Climate Cell 6: Export agriculture

A climate cell will always be coordinated by a representative of CCS. Other government representatives will be nominated by the heads of those agencies upon the request of the

Secretary of the Ministry of Environment. Non-governmental representatives will be invited by the Ministry of Environment. SCCs shall have the full responsibility of implementation of sector action plans with the coordination support from CCS.

9.3. National Working Group for Cross-cutting National Adaptation Needs (NWG)

National Working Group (NWG) will be a consortium of national lead agencies and non-state representatives, again coordinated by staff members of CCS. The NWG has the responsibility of implementation of adaptation actions relating to cross-cutting national issues. National lead agencies are the organizations that look after subjects with cross-cutting mandate. Some examples are Department of Meteorology (climate information), National Science Foundation (research) and Disaster Management Centre (disaster risk management). Cross-cutting issues are national level issues. As in the case of SCCs, government representatives shall be ex-officio members nominated by heads of lead agencies upon the request of Secretary, Environment whereas non-governmental members shall be appointed on invitation. Some lead agencies responsible for cross-cutting issues are:

- *Policy legislations and governance*: Ministry of Mahaweli Development and Environment, Climate Change Secretariat, Ministry of Policy Planning
- *Institutional development*: Ministry of Mahaweli Development and Environment, Climate Change Secretariat
- *International co-operation and partnerships*: External Resources Department, Ministry of Foreign Affairs
- *Resource mobilization*: Ministry of Finance, External Resources Department
- *Research and development*: Ministry of Science and Technology, National Science Foundation, National Research Council, National Science and Technology Commission
- *Technology transfer*: Ministry of Science and Technology, National Science Foundation, National Research Council, National Science and Technology Commission
- *Education, Training and awareness*: Ministry of Mass Media and Information, Ministry of Education, government media agencies, private media agencies, local and international non-governmental organizations, community based organizations
- *Extreme events management*: Ministry of Disaster Management, Disaster Management Centre, National Building Research Organization, Sri Lanka Land Reclamation and Development Corporation
- *Climate information management*: Department of Meteorology, Ministry of Disaster Management, Department of Agriculture, government media agencies, private media agencies
- *Building adaptive capacity*: Ministry of Local governments and Provincial Councils, local and international non-governmental organizations, community-based organizations, Ministry of Disaster Management

9.4. Regional Climate Cells (RCCs)

Regional Climate Cells (RCCs) will be set up according to the requirement for implementation of actions that are specific to a given regional area. These will be represented by the representatives of Provincial Councils, local government bodies, District and Divisional Secretariats in relevant areas upon the request of the Ministry of Mahaweli Development and Environment.

9.5. Civil Society Organizations (CSO) Forum

Forum of Civil Society Organizations (CSO), a group of partner agencies, will be a coordination body established to support actions that have grass root level operations. It will be established to support the implementation and coordination of community-based interventions involved with sectoral and cross-cutting levels proposed by NAP. It will function as a supporting body for both CACs and the NWG.

9.6. National Experts Committee on Climate Change Adaptation (NECCCA)

The National Experts Committee on Climate Change Adaptation (NECCCA) is an already appointed body of technical experts functioning in the advisory capacity to the Ministry of Mahaweli Development and Environment. The NECCCA will continue to function in the same advisory capacity and expected to fulfill an extended role with the launching of NAP. All other institutional bodies will be provided the opportunity for benefiting from the technical advices of the NECCCA through NFP and NSC. Technical Issues arising from implementation of the Plan will be forwarded to NECCCA that will be taken up in periodic meetings of the NECCCA or individual experts according to the technical subjects involved.

9.7. National Steering Committee (NSC)

National Steering Committee (NSC) will be the overall supervisory body of the plan implementation. It will be represented by the selected members of SCCs, RCCs, the NWG and CSOs appointed by the Ministry of Mahaweli Development and Environment. Members will be appointed to represent all sectors and regions as far as possible. The main roles of the NSC will be providing the overall leadership for implementation of the Plan, monitoring the progress of implementation, guiding the periodic review of the Plan according to the schedule and making decisions on necessary course correction adjustments.

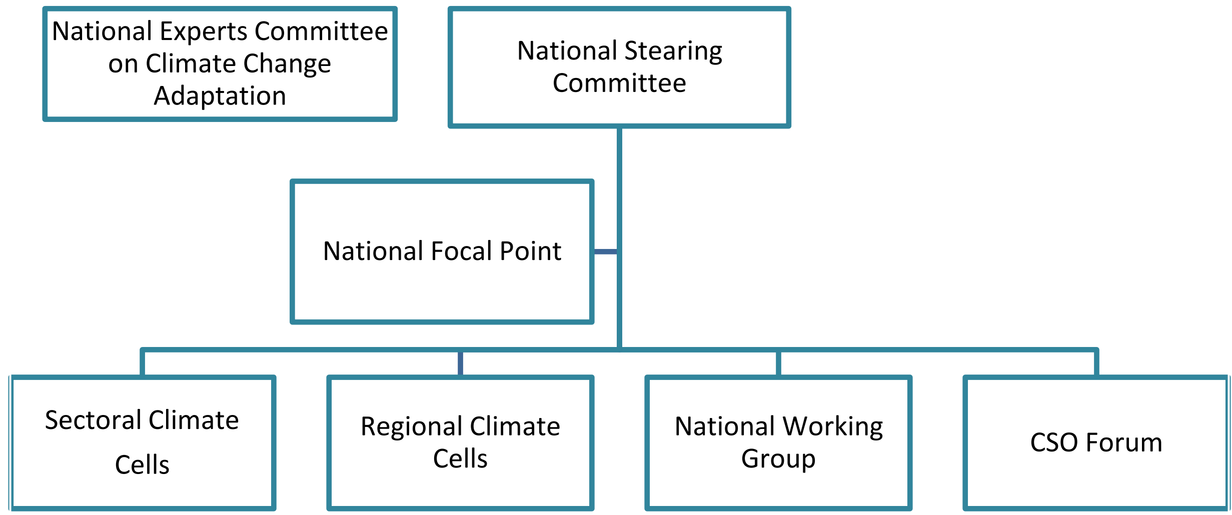


Figure 3: Structure of Institute and Coordination Mechanism

10.Implementation Strategy

The key objectives of the implementation strategy are efficient implementation of planned actions of adaptation on a realistic timeframe and ensuring the participation of all stakeholders from government, private sector, academia, civil society organizations and local communities to achieve the maximum level of cooperation.

The NAP identifies adaptation actions at three levels.

- Sector level actions: These actions are focused on individual sectors or joint sectoral actions
- National level actions: These actions are focused on cross-cutting issues
- Community level actions: Actions that are targeted at the grass-root level

10.1. Implementation of Sector Level Actions

Sector level actions will be implemented by SCCs. The role of CCS within a climate cell is facilitation and coordination. Climate cells will function as working groups on sectoral adaptation actions. Adaptation actions within a cell may involve interventions confined to individual sectors as well actions that need joint implementation with other cells (e.g. drinking water (water) and housing (human settlements). For actions confined to individual sectors, the responsible line agency (or agencies) may directly coordinate with CCS to implement the action within the purview of the cell. CCS may facilitate by helping to attract necessary financial opportunities and other resources. In case of actions that need joint implementation by agencies coming under different SCCs, the CCS, as the common coordinator of all cells, may facilitate creating inter-cell linkages. Hence, CCS is supposed fulfill intra-cell as well inter-cell coordination.

10.2. Implementation of National Level (cross-cutting) Actions

National level adaptation actions that deal with cross-cutting issues will be handled by the NWG. The convener of the working group is CCS and other members are national lead agencies. National level actions may require coordination among lead agencies within the NWG as well as coordination between lead agencies (of NWG) and sectoral line agencies (SCCs). Again the CCS shall act as the common facilitator within the NWG as well as between NWG and SCCs. This is critical for integrated actions and could help forging ‘fast track’ channels for fundraising from national and international sources.

10.3. Implementation of Regional Level Actions

Sector level actions will be implemented by SCCs. The role of CCS within a climate cell is facilitation and coordination. Climate cells will function as working groups on sectoral adaptation actions. Adaptation actions within a cell may involve interventions confined to individual sectors as well actions that need joint implementation with other cells (e.g. drinking water (water) and housing (human settlements).

10.4. Implementation of Community Level Actions

Membership of the NWG as well as SCCs shall include representatives from CSOs and community organizations. Besides, there is CSO Forum. Both, sectoral and national level actions may need working at the grass-root level with local communities and CSOs. Actions that need to be focused at the community level could use the help of community organizations and CSOs that include both national and international NGOs. These organizations can act as mobilizers for community level actions. The CSO forum provides an additional platform for coordination among such organizations.

10.5. Monitoring and Evaluation

The NAP is a rolling plan with a 10 year time horizon. Hence, setting up of a viable mechanism for monitoring the progress of implementation should be an essential component of the Plan. Moreover, given the uncertainties involved with climate change impacts and rapidly increasing knowledge on the subject, updating the Plan periodically to match the changing conditions, increased understanding of issues and new information acquired also is mandatory.

Progress monitoring of the Plan: Progress of the plan to be monitored against the time plan of actions presented in Tables A10-A19. Progress of the each sectoral plan and the cross-cutting plan are to be reviewed bi-annually by the respective SCCs and the NWG. Similarly, progress of regional and community-based actions is to be monitored every six months by RCCs and the CSO Forum. At the end of each year, progress of all sectors and the cross-cutting action plan shall be reviewed by the NSC at an Annual Progress Meeting where necessary path correction decisions will be taken. The progress reports will be submitted to the NECCCA for further advice and comments on the corrective course of action. To undertake the monitoring in an objective manner, all SCCs, RCCs, NWG and the CSO forum will have to prepare suitable log frame structures for each sector and cross-cutting area.

Periodic revision and updating of the Plan: The NAP as a rolling plan shall undergo two periodic revisions for updating the overall plan as follows.

First periodic revision: The first three years of the Plan will be the *Foundation Building Stage.* At the end of this phase plan will have to undergo and periodic revision and updating. This will take place in the final quarter of the third year and the updated plan will be submitted for approval of the Annual Progress

Meeting of the third year. The revision has to be undertaken through an extensive consultation of stakeholders at decision-making as well as field level.

***Second periodic revision*:** The Plan enters the *Development Stage* after the first periodic revision. At the end of this stage, the second periodic revision will be conducted. The second periodic revision of the NAP shall be carried out in the final quarter of the third year and the updated plan will be submitted for approval of the 6th Annual Progress Meeting.

***The post-plan review*:** The last four years of the plan will be the *Goal Achieving Stage*. After the completion of the 10th year of the Plan, a post-Plan review shall be undertaken to assess the overall achievements of the Plan and identify the lessons for future plans.

11. Resource Mobilization Mechanism

Resource mobilization is a major issue to be faced in all adaptation interventions in Sri Lanka. Therefore success of achieving the goals of the plan depends heavily on devising an effective mechanism for resource mobilization. It should be a proactive programme for acquiring resources necessary for implementation of the plan.

11.1. Types of Resources Needed

Implementation of NAP requires many resources in the form of financial, technical and human resources. Almost all the activities require financial resources while some may need technical and human resources also. Quite often, sourcing of the technical and human resources are conditional upon the access to financial resources. Therefore among resources, financial resources are the most critical for implementation of the adaptation actions both at national and sector levels. Following main sources are proposed in securing the necessary resources for adaptation actions.

11.2. Sources of Financing

National Adaptation Fund (NAF): The plan proposes to establish a National Adaptation Fund (NAF). The NAF will have seed funding from the government budget as an annual allocation for a specified period. In addition, the government shall seek co-financing from donor community to develop an endowment for supporting all types of adaptation actions in Sri Lanka. This fund will provide opportunities for fully funded initiatives and co-funded opportunities. For example, NAF will share a part of the cost of certain adaptation actions and the rest would come from local or an international funding source. The management of NAF will be a joint responsibility of the Ministry of Finance and Ministry of Environment. For both national and sectoral actions of NAP, allocation of money from NAF will be made upon the recommendation of CCS.

International adaptation funding opportunities: There are several international organizations that offer funding for adaptation interventions. Some examples are Asian Development Bank (ADB), World Bank (WB), GEF (UNDP), other United Nations organizations such as UNHABITAT, UNESCAP and Green Climate Fund (GCF). Both national adaptation actions and sectoral adaptation actions can be funded through these initiatives. Proposed national adaptation actions can be formulated in to project proposals and submitted for donor funding by the NWG or CACs. The CCS might not be able to approach these funding organizations directly, but through the External Resources Department (ERD), which is again a representative of the NWG. The same procedure can be followed for any adaptation actions to be implemented thorough CACs.

Funds for specialized adaptation related research and development: The National Science Foundation (NSF) and the National Research Council (NRC) are the two main government institutions that facilitate small and large grants for scientific research in Sri Lanka. These two institutes fall under the Ministry of Science and Technology and will be member institutions of the NWG. These organizations may help developing dedicated funding facilities for thematic research on climate change adaptation.

Private sector funding opportunities: Another source of funding is the corporate sector. Private sector organizations usually allocate funds for Cooperate Social Responsibility (CSR). Climate change adaptation projects can be a recipient of such CSR funding. However, this is not a fully explored channel and therefore creation of awareness would matter most. Approaching these institutions can be facilitated by CCS.

Funding through Community Service Organizations: While the size of support expected from these sources may be low in terms of cash, there is plenty of human resources that can be used through this channel. These types of funding opportunities are ideal for adaptation measures that are targeting community level actions.

Tentative budget estimates are given in Tables A10-A19 with the time plan of actions. The figures given in the tables are gross estimates validated by the stakeholders in the workshops. However, these figures cannot be entirely relied upon and they only offer comparative first estimates that should provide the foundation for working out detailed budgets for respective actions.

12. References

Abhayasinghe, K.R. (2007) Climate. In: The National Atlas of Sri Lanka. Survey Department of Sri Lanka, Colombo, Sri Lanka: 52-53.

Adger, W.N., S. Dessai, M. Goulden, M. Hulme, I. Lorenzoni, D.R. Nelson, L.O. Naess, J. Wolf and A. Wreford (2009) Are there social limits to adaptation to climate change? Climatic Change 93: 335-354.

Ahmed M. and S. Suphachalasai (2014) Assessing the Costs of Climate Change and Adaptation in South Asia. Asian Development Bank, Manila, Philippines.

Basnayake, B.R.S.B. (2007) Climate Change. In: The National Atlas of Sri Lanka. Survey Department of Sri Lanka, Colombo, Sri Lanka: 54-55

Basnayake, B. R. S. B.; Vithanage, J. C. (2004) Future climate scenarios of rainfall and temperature for Sri Lanka. Proceedings of the 60th Annual Session of Sri Lanka Association for the Advancement of Science (SLASS). Section E1., SLAAS, Colombo, Sri Lanka: pp 222.

Chandrapala, L. (2007a) Temperature. In *The National Atlas of Sri Lanka*. Survey Department of Sri Lanka, Colombo, Sri Lanka: 56-57

Chandrapala, L. (2007b) Rainfall. In *The National Atlas of Sri Lanka*. Survey Department of Sri Lanka, Colombo, Sri Lanka: 58-59

Chandrapala, L. (1996a) Calculation of areal precipitation of Sri Lanka on district basis using Voronoi Tessalation Method. Proceedings of National Symposium on Climate Change, Central Environmental Authority, Colombo, Sri Lanka. March 7-8, 1996.

Chandrapala, L. (1996b) Long term trends of rainfall and temperature in Sri Lanka. In: Y.P.Abrol, S. Gadgil and G. B. Pant (eds.). Climate Variability and Agriculture, New Delhi, India: Narosa Publishing House: pp 153-162.

Cruz, R. V., H. Harasawa., M. Lal., S. Wu., Y. Anokhin., B. Punsalmaa., Y. Honda., M. Jafari., C. Li and N. Huu Ninh (2007) Asia. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Parry, M. L., O. F Canziani., J. P. Palutikof., P. J. Van der Linden and C. E. Hanson. (Eds.) Cambridge, UK: Cambridge University Press. pp 469-506.

De Costa, W.A.J.M. (2008) Climate change in Sri Lanka: myth or reality? Evidence from long-term meteorological data. J. Nat. Sci. Found. Sri Lanka, 36: 63–88.

De Silva, C.S. (2006 b) Impacts of climate change on water resources in Sri Lanka. Paper presented at the 32nd WEDC International Conference, November 13-17, 2006, Colombo, Sri Lanka.

Eriyagama, N., V. Smakhtin., L. Chandrapala and K. Fernando (2010) Impacts of climate change on water resources and agriculture in Sri Lanka: a review and preliminary vulnerability mapping. Colombo, Sri Lanka: International Water Management Institute: 51pp. (IWMI Research Report 135). [doi:10.5337/2010.211]

Hijioka, Y., E. Lin., J.J. Pereira., R.T. Corlett., X. Cui., G.E. Insarov., R.D. Lasco., E. Lindgren and A. Surjan (2014) Asia. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part

B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1327-1370

Imbulana, K.A.U.S., N.T.S. Wijesekara., B.R. Neupane (2006) Sri Lanka Water Development Report 2010. UNESCO and Ministry of Irrigation and Water Resources Mangement, Colombo, Sri Lanka

IPCC (2007) Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Core Writing Team. Pachauri, R.K and A. Reisinger (Eds.) Geneva, Switzerland: IPCC. 104 pp.

IPCC (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. In: Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir,M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy,S. MacCracken, P.R. Mastrandrea, and L.L. White (Eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

Jayatilake, H.M., L. Chandrapala., B.R.S.B. Basnayake and G.H.P. Dharmaratne (2005) Water Resources and Climate Change. In: S. Wijesekara, K.A.U.S. Imbulana and Bhanu Neupane (eds). *Proceedings of the preparatory workshop on Sri Lanka national water development report.* Ministry of Irrigation, Mahaweli and Rajarata Development, Colombo, Sri Lanka: 62-87

LDCEG (2012) National Adaptation Plans: Technical Guidelines for the National Adaptation Plan Process. UNFCCC Secretariat, Bonn, Germany.

Jayathunga, R.D.S. and N. Kumari (2013) Present status of climate related policy, legal institutional and research initiatives of Sri Lanka. In: H.P.M. Gunasena, H.A.J. Gunathilake, J.M.D.T. Everard, C.S. Ranasinghe and A.D. Nainanayake (eds) Proceedings of the International Conference on Climate Change Impacts and Adaptation for Food and Environmental Security, Colombo, pp 125–135.

Marambe, B., G. Pushpakumara and P. Silva (2012) Biodiversity and Agro-biodiversity in Sri Lanka: A case in Village Tank Systems. In: S-I Nakano, T. Yahara, and T. Nakashizuka (eds) Biodiversity Observation Network in the Asia-Pacific Region: Towards Further Development of Monitoring. Springer, Japan. pp 403-430

Marambe. B,, G. Pushpakumara, P. Silva, J. Weerahewa and R. Punyawardena (2013) Climate change and household food security in homegardens of Sri Lanka. In: H.P.M. Gunasena, H.A.J. Gunathilake, J.M.D.T. Everard, C.S. Ranasinghe and A.D. Nainanayake (eds) Proceedings of the International Conference on Climate Change Impacts and Adaptation for Food and Environmental Security, Colombo, pp 87–100.

Marambe, B., R. Punyawardena, P. Silva, S. Premalal, V. Rathnabharathie, B. Kekulandala, U. Nidumolu and M. Howden (2015a) Climate, climate risk, and food security in Sri Lanka: need for strengthening adaptation strategies. In: W. Leal (ed.) Handbook of Climate Change Adaptation Springer-Verlag Berlin Heidelberg. pp 1959-1789

Marambe, B., P. Silva, J. Weerahewa, G. Pushpakumara, R. Punyawardena and R. Pallawala

(2015b) Enabling policies for agricultural adaptations to climate change in Sri Lanka. In: W. Leal (ed.) Handbook of Climate Change Adaptation Springer-Verlag Berlin Heidelberg

ME (2010 a) Sector Vulnerability Profile: Agriculture and Fisheries. Ministry of Environment, Colombo, Sri Lanka.

ME (2010 b) Sector Vulnerability Profile: Urban Development, Human Settlements and Infrastructure. Ministry of Environment, Colombo, Sri Lanka.

ME (2010 c) Sector Vulnerability Profile: Health. Ministry of Environment, Colombo, Sri Lanka

ME (2010 d) National Climate Change Adaptation Strategy for Sri Lanka. Ministry of Environment, Colombo, Sri Lanka.

ME (2012). The National Climate Change Policy of Sri Lanka. Ministry of Environment, Colombo, Sri Lanka.

MENR (2014) *National Action Program (NAP) for Combating Land Degradation in Sri Lanka*. Ministry of Environment and Renewable Energy, Colombo, Sri Lanka

Mutuwatte, L.P and P.K.N.C. Liyanage (2013) Impacts of Climate Change on Agro-Ecological Regions of Sri Lanka. In: H.P.M. Gunasena, H.A.J. Gunatilake, J.M.D.T. Everard , C.S. Ransinghe and A.D. Nainanayake (eds.) Proceedings of the International Conference on Climate Change Impacts and Adaptations for Food and Environmental Security. Coconut Research Institute, Lunuwila, Sri Lanka.

NCSD (2009) National Action Plan for Haritha Lanka Programme. National Council for Sustainable Development, The Presidential Secretariat, Colombo, Sri Lanka.

Nissanka, S. P., B.V.R. Punyawardena., K.H.M.S Premalal and R.O. Thattil (2011) Recent trends in annual and growing seasons' rainfall of Sri Lanka. Proceedings of the International Conference on the Impact of Climate Change in Agriculture. Faculty of Agriculture, University of Ruhuna, Mapalana, Sri Lanka. December 20, 2011. Pages 249-263

Premalal, K.H.M.S. (2009) Weather and climate trends, climate controls and risks in Sri Lanka. Presentation made at the Sri Lanka Monsoon Forum, April 2009. Department of Meteorology, Sri Lanka.

Premalal, K.H.M.S. and B.V.R. Punyawardena (2013) Occurrence of extreme climatic events in Sri Lanka. In: H.p.M. Gunasena, H.A.J. Gunathilake, J.M.D.T. Everard, C.S. Ranasinghe and A.D. Nainanayake (eds), Proceedings of the International Conference on Climate Change Impacts and Adaptations for Food and Environment Security. Hotel Renuka, Colombo, pp. 49-57.

Punyawardena, B.V.R., S. Mehmood, A.K., Hettiarachchi, M, Iqbal, S.H.S.A Silva, and A. Goheer (2013a) Future Climate of Sri Lanka: An approach through dynamic downscaling of ECHAM4 General Circulation Model (GCM). *Tropical Agriculturist* 161: 35-50

Punyawardena, B.V.R., T. Dissanaike and A. Mallawatantri (2013b) Spatial variation climate change induced vulnerability in Sri Lanka.; An analysis of the components of vulnerability at district level. Published by the Department of Agriculture in collaboration with UNDP/SGP, Sri Lanka

Punyawardena, B.V.R. and K.H.M.S. Premalal (2013) Do trends in extreme positive rainfall anomalies in the Central highlands of Sri Lanka exist? Annals of the Sri Lanka Department of Agriculture, 15: 1-12

Ranasinghe, C.S. (2013): Impact of climate change in coconut and identification of adaptation measures with special emphasis on reproductive development. In: H.p.M. Gunasena, H.A.J. Gunathilake, J.M.D.T. Everard, C.S. Ranasinghe and A.D. Nainanayake (eds), Proceedings of the International Conference on Climate Change Impacts and Adaptations for Food and Environment Security. Hotel Renuka, Colombo, pp. 101-113.

Ratnayake, U. and Herath, G. (2005) Changes in Water Cycle: Effect on Natural Disasters and Ecosystems. *In* S. Wijesekara, K.A.U.S. Imbulana, B. Neupane (eds.), Proceedings of the Preparatory Workshop on Sri Lanka National Water Development Report, World Water Assessment Programme, Paris, France: 192-205.

Sathischandra, S.G.A.S., Marambe, B. and Punyawardena R. (2014): Seasonal changes in temperature and rainfall and its relationship with the incidence of weeds and insect pests in rice (*Oryza sativa* L) cultivation in Sri Lanka. Climate Change and Environmental Sustainability 2(2): 105-115

Shantha, W. W. A. and Jayasundara J. M. S. B. (2005). Study on changes of rainfall in the Mahaweli upper watershed in Sri Lanka due to climatic changes and develop a correction model for global warming. Paper presented at the International Symposium on the Stabilisation of Greenhouse Gas Concentrations. Hadley Centre, Met Office, Exeter, UK.

Senaratne, A., N. Perera and K. Wickramasinghe (2009) Mainstreaming Climate Change for Sustainable Development in Sri Lanka: Towards a National Agenda for Action. *Research Studies: Working Paper Series No. 14.* Institute of Policy Studies of Sri Lanka, Colombo, Sri Lanka.

Smit, B., I. Burton, R.J.T. Klein and J. Wandel (2000) An anatomy of adaptation to climate change and variability. Climate Change 45: 223-251

Smith, J.B., N. Bhatti, G. Menzhulin, R. Benioff, M.I. Budyko, M. Campos, B. Jallow and F. Rijsberman (eds.), 1996: Adapting to Climate Change: An International Perspective. Springer- Verlag, New York, NY, USA, 475 pp

Stakhiv, E.Z. (1993) Water resources planning and management under climate uncertainty. In: T.M. Ballentine and E.Z. Stakhiv (eds.). Proceedings of the First National Conference on Climate Change and Water Resources Management, U.S. Army Corps of Engineers Institute for Water Resources, Fort Belvoir, VA.

UNCCS (2012) The National Adaptation Plan Process: A Brief Overview. United Nations Climate Change Secretariat, Bonn, Germany.

Weerahewa, J., Pushpakumara, G., Silva, P., Daulagala, C., Punyawardena, R., Premalal, S., Miah, G., Roy, J., Jana, S. and Marambe, B. (2012): Are Homegarden Ecosystems Resilient to Climate Change? An Analysis of the adaptation strategies of homegardeners in Sri Lanka. APN Science Bulletin 2: 22-27

Wijeratne, A., A. Anandacoomaraswamy, M.K.S.L.D. Amarathunga, J. Ratnasiri, B.R.S.B. Basnayake and N. Kalra (2007) Assessment of impact of climate change on productivity of tea (*Camellia sinensis* L.) plantations in Sri Lanka. J. Natn. Sci. Foundation Sri Lanka 35(2): 119-126.

WMO (2014) WMO Statement on the Status of the Global Climate in 2013. World Meteorological Organization. Geneva, Switzerland

Zubair, L., J. Hansen., J. Chandimala., M.R.A. Siraj., M. Siriwardhana., K. Ariyaratne., I. Bandara.,

H. Bulathsinghala., T. Abeyratne., T.D.M.A. Samuel (2005) Current climate and climate change assessments for coconut and tea plantations in Sri Lanka. IRI, FECT, NRMS and UoP Contribution to AS12 Project Report to be submitted to START, Washington, DC., USA.

13. Appendices

Table A-1: Physical effects, impacts, adaptation needs and adaptation options – Food security

Physical effects	Physical hazards/vulnerabilities	Impacts	Socio-economic outcomes	Adaptation need	Adaptation options
• **Increased day and night air temperature** • **Increased evaporation and evapo-transpiration** • **Regular and extended dry spells** • **Increased frequency and severity of droughts**	• Increased thermal/heat stress on crops • Increased thermal/heat stress on animals • Increase water stress on crops • Regular shortages of water • Decrease in water availability in reservoirs • Reduction of soil moisture • Increased soil salinity • Decreased soil quality	• Decline of crop productivity • Decline of animal productivity • Decline of fish productivity in reservoir fisheries • Regular Crop losses	• Loss income to farmers • Loss of income to livestock producers • Loss of income to inland fishermen • Loss of livelihood opportunities	1. Enhance the resilience of crops, animals, fish and agro-ecosystems against heat and water stress	A. Germplasm improvement B. Improvement of farm water management C. Promotion of resource efficient farming systems D. Sectoral Capacity development
• **Alteration of thermal ranges for biological organisms (pests, pathogens, parasites, vectors)**	• Increased risk of pest and disease attacks on crops • Increased risk of parasite and disease attacks on livestock	• Increased crop damage due to pests and diseases • Increased health risks of farm animals	• Increased cost of plant protection • Increased cost of animal health management	2. Minimize the risk of crop and health damage due to biological agents	A. Germplasm improvement B. Strengthening of supporting facilities C. Promotion of best practices

• **Irregular/erratic changes in established rainfall patterns**	• Impacts on flowering of crops • Changing pasture availability for livestock	• Decline of crop productivity • Crop losses • Fluctuation in animal production	• Loss income to farmers • Loss of income to livestock producers	3. Minimize the impact on food security due to erratic changes in precipitation	A. Climate information management B. Improvement of pasture and fodder management
• **Regular incidents of intense rainfall with high cloud cover** • **Increased frequency and severity of floods** • **Increased frequency and severity of droughts** • **Cyclones and high winds**	• Increased drainage and water logging problems • Increased soil erosion • Increased susceptibility of crops and livestock to floods hazards • Increased susceptibility of crops and livestock to droughts • Landslides • Turbulent conditions in the sea	• Decline of crop productivity • Crop losses • Decline of animal productivity • Decline of fish productivity in reservoir fisheries • Loss of livestock assets • Depletion of fish stock in reservoirs	• Life and property damages • Loss income to farmers • Loss of income to livestock producers • Disturbance to livelihood of fishermen • Loss income to fishermen	4. Enhance the resilience of crops, animals, fish and agro-ecosystems to extreme weather events	A. Germplasm improvement B. Establishment of an efficient climate information management and communication system C. Improvement of disaster risk preparedness and management
• **Salt water intrusion** • **Inundation of low-lying areas**	• Increased soil salinity in coastal areas • Increased water salinity in coastal areas • Increased coastal erosion • Damage to coastal habitats	• Decline in agricultural productivity • Salinity development in agricultural lands • Damage to livelihoods based on coastal habitats	• Loss income to farmers • Loss of agricultural lands • impacts on livelihoods of coastal and lagoon fishermen	5. Minimize the impacts of sea level rise on agriculture in coastal zone	A. Germplasm improvement B. Strengthening the monitoring of climate impacts C. Exploring alternatives

• **Ocean acidification** • **Physiochemical changes in oceanic environment**	• Damage to coral reefs • Structural changes oceanic habitats and composition of species	• Changes in reef fish stocks • Stock changes in economically important species	• Impacts on livelihoods to fishermen	6. Assess the changes in oceanic environment and impacts on livelihoods and food security	C. Initiating research studies to assess climate impacts D. Strengthening the monitoring of climate impacts
• **Rising atmospheric CO_2 concentration**	• Increased photosynthesis in certain plant categories	• Increased productivity in certain crops • Increased weed populations	• Income gains for farmers • Increased cost of plant protection	7. Assess the impacts of rising atmospheric CO_2 on productivity crops and weed populations	A. Initiating research studies to assess climate impacts

Table A-2: Physical effects, impacts, adaptation needs and adaptation options – Water resources

Physical effects	Physical hazards/vulnerabilities	Impacts	Socio-economic outcomes	Adaptation need	Adaptation options
• **Increased day and night air temperature** • **Increased evaporation and evapo-transpiration** • **Regular and extended dry spells** • **Increased frequency and severity of droughts** • **Irregular/erratic changes in established rainfall patterns**	• Regular fluctuation of water availability in major/medium reservoirs • Rapid dry out of minor irrigation facilities • Poor and disturbed flow in streams • Decreased quality of water due to high salinity • Depletion of ground water sources	• Decreased availability of safe water for human consumption • Decreased availability of water for irrigation • Decreased availability of water for industrial supply • Decreased water quality and safety	• Supply constraints of safe water for domestic use • Loss of income for farmers • Loss of livelihood opportunities • Increased cost of industrial water supply	1. Enhance the resilience of systems for water supply, management and use to overcome the scarcities caused by climate change impacts	A. Improvement of watershed management B. Capacity development of storage facilities C. Initiating research studies to assess climate impacts D. Strengthening the monitoring of climate impacts E. Promote efficient practices of water management and use

• **Regular incidents of intense rainfall** • **Increased frequency and severity of floods** • **Increased frequency cyclones and high winds**	• Problems of drainage and water logging conditions. • Rapid siltation of reservoirs • Damage to irrigation structures • Damage to domestic and industrial water supply structures • Decrease in quality of water due to – sediment wash off – Pollution of drinking water	• Wastage (unutilized) of water in periods of excess rainfall • Disturbances domestic water supply • Disturbances to irrigation • Disturbance to industrial water supply • Loss of storage capacity of reservoirs	• Problems of water quality and safety for human consumption • Increased cost of rehabilitation and maintenance • Increased cost of drainage • Life and property damages	2. Ensure the safety of water management facilities and minimize disturbances to supply due to extreme weather events	A. Strengthening the monitoring of climate impacts B. Establishment of an efficient climate information and communication system C. Improvement of disaster risk preparedness and management D. Capacity development of storage facilities
• **Salt water intrusion** • **Inundation of low-lying areas**	• Decline of water quality due to increased salinity • Damage to irrigation structures • Damage to domestic and industrial water supply facilities	• Decreased availability of fresh water for human consumption • Decreased availability of water for irrigation due to high salinity • Decreased quality of water for industrial supply	• Supply constraints of safe water for domestic use • Loss of income for farmers • Increased cost of industrial water supply	3. Minimize the impacts of sea level rise on water supply and management in coastal zone	A. Strengthening the monitoring of climate impacts B. Improve salinity protection measures in coastal areas

Table A-3: Physical effects, impacts, adaptation needs and adaptation options – Coastal and marine sector

Physical effects	Physical hazards/vulnerabilities	Impacts	Socio-economic outcomes	Adaptation need	Adaptation options
• **Inundation of low-lying areas (sea level rise)**	• Shoreline retreat • Increased coastal erosion • Damage to coastal habitats (estuaries& lagoons, mangroves, salt marshes, beaches, sand dunes, coral reefs, sea grass beds, deltas, islands, barrier beaches and spits) • Effects on estuaries and river mouths	• Damages to coastal protection structures • Decline in beach stability • Loss of eco-system services • Loss of lands	• Impacts on livelihoods of local communities • Increased cost of coastal protection • Increased scarcity of lands	1. Strengthen the coastal zone management to face the impacts of sea level rise	A. Initiating research studies to assess impacts of sea level rise B. Establishment of a sea level rise monitoring system C. Strengthening the coastal protection and management D. Participatory management of sensitive coastal habitats
• **Irregular/erratic changes in established rainfall patterns** • **Regular incidents of intense rainfall** • **Increased incidence of cyclones and high winds**	• Increased incidence of storm surges, tidal waves and turbulent conditions. • Damage to coastal habitats (estuaries& lagoons, mangroves, salt marshes, beaches, sand dunes, coral reefs, sea grass beds, deltas, islands, barrier beaches and spits)	• Damages to coastal protection structures • Decline in beach stability • Loss of eco-system services	• Loss of livelihoods/income to extractors of coastal resources • Increased cost of coastal protection	2. Enhance the resilience of coastal systems against increased extreme events	A. Improvement of disaster risk preparedness and management

Table A-4: Physical effects, impacts, adaptation needs and adaptation options – Health

Physical effects	Physical hazards/vulnerabilities	Impacts	Socio-economic outcomes	Adaptation need	Adaptation options
• **Irregular/erratic changes in precipitation pattern** • **Alteration of thermal ranges for biological organisms (pests, pathogens, parasites, vectors)** • **Boundary shift in climatic zones**	• Increased risk of spreading of existing vector borne-diseases (e.g. Dengue, malaria) • Increased risk spreading of pathogenic diseases • Risk of new areas becoming susceptible to vector bone and pathogenic diseases • Increased risk of new vector bone disease outbreaks (e.g. leishmaniasis)	• Increased mortality due to vector borne and pathogenic diseases • Increased morbidity due to vector borne and pathogenic diseases • Reduced capacity of victims for productive work	• Increased cost of prevention and treatment • Loss of value and income due to reduced number of workdays • Psychological trauma and stress due to victimization	1. Assess and prepare for the health risks due to increased vector bone and pathogenic diseases	A. Conducting research studies to assess the risk of climate-induced diseases B. Strengthening the surveillance and monitoring of climate- induced diseases C. Capacity development for managing climate-induced disease incidents
• **Increased frequency and severity of floods** • **Cyclones and high winds** • **Lightening** • **Landslides**	• Increased risk of outbreaks of food and water borne diseases • Increased number of injuries and mortalities due to victimization to hazard events • Health and sanitation problems due to poor access to water	• Increased susceptibility to health hazards among disaster victims	• Increased cost of health care management and treatment of victims • Psychological trauma and stress due to victimization	2. Minimize the health hazards associated with increased incidence of extreme events	A. Establishing an efficient climate information and communication system B. Improvement of disaster risk preparedness of health related agencies and workers

• **Increased concentration of climate altering pollutants**	• Increased risk of diseases and ill-health conditions (e.g. respiratory, cardio-vascular, skin diseases, neurological, carcinogenic)	• Increased mortality due to diseases and ill-health conditions • Increased morbidity due to diseases and ill-health conditions • Reduced capacity of victims for productive work	• Increased cost of prevention and treatment • Loss of value and income due to reduced number of workdays • Psychological trauma and stress due to victimization	3. Assess and prepare for health risks caused by concentration of climate altering pollutants	A. Conducting research studies to assess health impacts of climate altering pollutants B. Improvement of monitoring of climate altering pollutants C. Capacity development for managing health impacts of climate altering pollutants
• **Increased day and night air temperature** • **Increased concentration of dust/ soil particles in atmosphere** • **Heat island effect**	• Increased risk of ill-health conditions due to heat stress • Probability for decline in cold related diseases, (e.g. influenza, common cold) • Increased risk of respiratory and eye diseases	• high rate of morbidity • Reduced capacity of victims for productive work	• Increased cost of prevention and treatment • Loss of value and income due to reduced number of workdays • Psychological trauma and stress due to victimization	4. Assess the impact on health due to increased heat and thermal stress	A. Conducting research studies to assess health impacts of heat/thermal stresses and to protect the victims

Table A-5: Physical effects, impacts, adaptation needs and adaptation options – Human settlements and infrastructure

Physical effects	Physical hazards/vulnerabilities	Impacts	Socio-economic outcomes	Adaptation need	Adaptation options
• **Increased day and night air temperature** • **Increased evaporation and evapo-transpiration** • **Regular and extended dry spells** • **Increased frequency and severity of droughts** • **Increased concentration of dust/ soil particles in atmosphere** • **Heat island effect**	• Increased thermal stress on residents • Accelerated deterioration of infrastructure facilities: e.g. thermal cracks • Increased thermal stress on domestic animals • Increased exposure to pollutants • Increased exposure to air pollution due to poor wind movements	• Decrease in living comfort • Increased dependence on indoor living environments • Reduction in walkability and cyclability • Increased demand for energy and water supply	• Increased cost on indoor environment controlling facilities • Increased maintenance costs of infrastructure • Increased cost of sanitation and healthcare of domestic animals • Increased cost on energy and water supply • Increased cost of protection from pollution	1. Enhance the resilience of human settlements and infrastructure against heat and water stress	A. Improvement and promotion of building designs and the environment (landscaping etc.) for climate resilience B. Revision of procedures and guidelines C. Initiating research studies to assess climate impacts D. Sectoral Capacity development
• **Irregular/erratic changes in established rainfall patterns** • **Regular incidents of intense rainfall with high cloud cover**	• Impacts on drainage and sewerage systems • Accelerated deterioration of infrastructure facilities	• Decrease in living comfort • Increased dependence on indoor living environments • Reduction in walkability and cyclability • Periodic overcrowding of the capacity of Infrastructure facilities. E.g. Drainage system	• Increased maintenance costs of infrastructure facilities • Disturbance to livelihoods of rural, estate and urban poor	2. Minimize the impacts on human settlements and infrastructure due to erratic changes in precipitation	A. Enhance the capacity of infrastructure in urban settlements B. Promote water safety and efficient utilization of surplus water

• **Increased frequency and severity of floods** • **Increased frequency and severity of droughts** • **Cyclones and high winds** • **Land slides**	• Damage to housing and settlements • Damage to infrastructure facilities • Decline of water quality • Damages to critical social facilities: health, security, education, communication	• Increased incidences of diseases and injury • Increased demand for health and sanitation facilities • Problems of supply/distribution of water	• Life damages • Displacement of people • Damage to property and livelihood assets • Loss of livelihoods and income • Increased rehabilitation and maintenance cost	3. Enhance the resilience of human settlements and infrastructure to extreme weather events	A. Promotion of disaster resilient buildings and construction B. Improvement of disaster risk preparedness and management
• **Salt water intrusion** • **Inundation of low-lying areas**	• Damage to housing and settlements • Damage to near-shore infrastructure • Impacts on sea outfalls • Increased salinity of water sources • Accelerated deterioration of structures – concrete, steel materials	• Impacts on settlements – fishers, tourism • Problems of water supply – both pipe borne and well water	• Damage to property and livelihood assets • Loss of lands • Displacement of people and unplanned settlements • Increased maintenance costs of structures	4. Minimize the impacts of sea level rise on coastal settlements and infrastructure	A. Increase the resilience of coastal settlements B. Strengthening the monitoring of sea level rise

Table A-6: Physical effects, impacts, adaptation needs and adaptation options – Ecosystems and biodiversity

Physical effects	Physical hazards/vulnerabilities	Impacts	Socio-economic outcomes	Adaptation need	Adaptation options
• **Increased day and night air temperature** • **Increased evaporation and evapo-transpiration** • **Alteration of thermal ranges for biological organisms** • **Regular and extended dry spells** • **Increased frequency and severity of droughts** • **Irregular/erratic changes in established rainfall patterns** • **Boundary shift in climatic zones**	• Increased thermal/heat stress on flora • Increased thermal/heat stress on fauna • Changes in structure and composition of natural ecosystems • Changes in spatial distribution of natural vegetation • Drying out of wetlands due to increased evaporation • Eutrophication of water bodies and wetlands • Coral bleaching • Migration of species • Forest die-back • Migration of species due to water stress • Drying out of streams	• Decline of ecosystem services • Increased risk of wild fires • Loss of aesthetic value • Risk of extinction of species • Decreased availability of water to surrounding areas • Increased risk of human wildlife conflicts	• Impacts on livelihoods of local communities • Problems of water scarcity for local communities • Increase cost of managing wild fires • Life and property damages • Crop and livestock losses	1. Enhance the resilience of natural ecosystems and biodiversity against climate change impacts	A. Initiating research studies to assess climate impacts B. Extend the existing biodiversity protection interventions to cover climate change impacts C. Strengthening the monitoring of climate impacts D. Enhance the participation of local communities in monitoring, conservation and management of biodiversity E. Promotion of traditional methods of biodiversity conservation for increased resilience in agro-ecosystems F. Sectoral Capacity development

• **Regular incidents of intense rainfall with high cloud cover** • **Increased frequency and severity of floods** • **Increased frequency and severity of droughts** • **Cyclones and high winds**	• Physical damages to natural ecosystems • Increased mortality and stress on fauna • Migration of species	• Decline of ecosystem services • Negative externalities on local communities	• Impacts on livelihoods of local communities	2. Enhance the resilience of natural ecosystems against extreme weather events	G. Improvement of disaster risk preparedness and management
• **Salt water intrusion** • **Inundation of low-lying areas**	• Increased salinity levels in coastal ecosystems • Structural changes in coastal habitats and composition of species	• Changes in coastal biodiversity • Loss of eco-system services	• impacts on livelihoods of coastal resource extractors	3. Minimize the impacts of sea level rise on coastal bio-diversity and ecosystem services	A. Initiating research studies to assess climate impacts B. Strengthening the monitoring of climate impacts
• **Physiochemical changes in oceanic environment**	• Structural changes oceanic habitats and composition of species	• Changes in oceanic biodiversity and food chains	• Impacts on livelihoods to fishermen	4. Assess the impact of thermal changes in oceanic bio-diversity and food chains	A. Initiating research studies to assess climate impacts B. Strengthening the monitoring of climate impacts

• **Rising atmospheric CO_2 concentration**	• Increased photosynthesis in certain plant categories	• Increased biomass production of natural vegetation • Spread of invasive alien species (C3 species)	• Increased harvest from economically useful species • Income gains for local communities • Increase cost of controlling invasive alien species	5. Assess the impacts of rising atmospheric CO_2 on biomass production of natural vegetation and spread of invasive alien species	A. Initiating research studies to assess climate impacts

Table A-7: Physical effects, impacts, adaptation needs and adaptation options – Tourism and recreation

Physical effects	Physical hazards/vulnerabilities	Impacts	Socio-economic outcomes	Adaptation need	Adaptation options
• **Increased day and night air temperature** • **Regular and extended dry spells** • **Increased frequency and severity of droughts** • **Inundation of low-lying coastal areas Ocean acidification** • **Progressive increase in acidity of rainfall**	• Degradation of natural ecosystems and biodiversity • Drying out of wetlands • Eutrophication of water bodies and wetlands • Forest die-back • Drying out of streams • Destruction of coastal ecosystems • Loss of beaches and recreational areas • Destruction of coral reefs • Damages to monuments and archeological assets	• Decline of scenic attractions and aesthetic value • Decline of cultural assets • Loss of recreation opportunities • Damages to tourism infrastructure	• Decline of attractiveness as a tourism destination • Losses in tourism operations • Livelihoods impacts on local communities involved in tourism • Reduced earnings from tourism	1. Adjustment of tourism and recreation industry to altered conditions of the destination	A. Initiating research studies to assess climate impacts B. Operational adjustments in the industry C. Changing of promotional strategies
• **Irregular/erratic changes in established rainfall patterns** • **Increased frequency and severity of floods** • **Cyclones and high winds** • **Land slides**	• Creation of unsuitable conditions for travelling • Creation of unsuitable conditions for recreation • Increased incidents of disaster situations	• Restrictions on aviation • Restrictions on local travelling • Restrictions on undertaking recreational activities • Increased of emergencies in travelling	• Disturbances to tourism operations • Impacts on livelihoods of local communities	2. Increase the preparedness of tourism and recreation operations to extreme weather conditions	A. Improvement of disaster risk preparedness and management B. Establishment of an efficient climate information management and communication system

Table A-8: Physical effects, impacts, adaptation needs and adaptation options – Export development sector

Physical effects	Physical hazards/vulnerabilities	Impacts	Socio-economic outcomes	Adaptation need	Adaptation options
• **Increased day and night air temperature** • **Increased evaporation and evapo-transpiration** • **Regular and extended dry spells** • **Increased frequency and severity of droughts**	• Increased thermal/heat stress on crops • Increase water stress on crops • Regular shortages of water for extended periods • Reduction of soil moisture • Increased soil salinity • Decreased soil quality	• Decline of crop productivity (tea, rubber, coconut, spices, sugar and cashew) • Decline of the quality of products • High mortality and low survival in nursery and replanting operations • Potential increases in productivity of up country tea (WU)	• Loss of income for plantation workers and small scale producers • Decrease in export earnings • Increased cost of production • Potential Increase in earnings of up country tea (WU)	1. Enhance the resilience of export agricultural crops against the impacts of heat and water stress	A. Germplasm improvement B. Improvement of farm and nursery management practices C. Initiating research studies to assess climate impacts D. Sectoral Capacity development
• **Alteration of thermal ranges for biological organisms (pests, pathogens, weeds)**	• Increased risk of pest and disease attacks on crops	• Increased crop damage due to pests and diseases	• Increased cost of plant protection	2. Minimize the risk of crop damage due to biological agents	A. Germplasm improvement B. Improvement of farm and nursery management practices C. Monitoring and surveillance of pest and disease

• **Irregular/erratic changes in established rainfall patterns** • **Regular incidents of intense rainfall with high cloud cover**	• Low solar radiation • Drainage problems • High soil erosion • High number days with intense rainfall: increased vulnerability to rainfall shocks • High humidity and moisture • Disturbance to cultural operations • Problems of pollination • Increased vulnerability of new plantations in non-traditional areas	• Decline of crop productivity (tea, rubber, coconut, spices, sugar and cashew) • Decline of the quality of products • High mortality and low survival in nursery and replanting operations • Increased risk of diseases • Loss of number of harvesting days	• Loss of income for plantation workers and small scale producers • Decrease in export earnings • Increased cost of production	3. Minimize the impact on export earnings from agriculture due to erratic changes in precipitation patterns	A. Establishment of an efficient climate information management and communication system B. Improvements in cropping systems
• **Increased frequency and severity of floods** • **Increased frequency and severity of droughts** • **Cyclones and high winds**	• Increased drainage and water logging problems • Increased soil erosion • Increased susceptibility of crops to flood hazards • Increased susceptibility of crops to droughts • Landslides	• Physical damage to plantations and trees • Crop losses due to floods • Crop losses due to drought • Chronic declining of the vigor of plants • Fire damage on crops • Decline in Quality of products • High mortality and low survival in nursery and replanting operations • Loss of agricultural lands hilly areas	• Damage to plantations Properties • Loss of income for plantation workers and small scale producers • Decrease in export earnings • Increased cost of production	4. Enhance the resilience of export agricultural crops to extreme weather events	A. Establishment of an efficient climate information management and communication system B. Improvement of disaster risk preparedness and management

• **Salt water intrusion** • **Inundation of low-lying areas**	• Increased soil salinity in coastal areas • Increased water salinity in coastal areas • Inundation of agricultural lands	• Decline in agricultural productivity • Salinity development in agricultural lands • Loss of agricultural lands (coconut, cinnamon, cashew)	• Loss of income for producers and plantation workers in coastal areas	5. Minimize the impacts of sea level rise on export agricultural crops in coastal zone	A. Strengthening the monitoring of climate impacts B. Development of protection structures

Table A-9: Physical effects, impacts, adaptation needs and adaptation options – Industry, energy and transportation

Physical effects	Physical hazards/vulnerabilities	Impacts	Socio-economic outcomes	Adaptation need	Adaptation options
• **Increased day and night air temperature** • **Increased evaporation and evapo-transpiration** • **Regular and extended dry spells** • **Increased frequency and severity of droughts** • **Irregular/erratic changes in established rainfall patterns**	• Regular fluctuation of water availability in hydro power reservoirs • Increased thermal/heat and water stress on crops and animals • Increased thermal/heat stress in industrial facilities	• Fluctuation in hydro power generation potential • Supply irregularities in agro-based raw materials	• Reduction in low cost hydro power generation • Decline in agro-based industrial production • Increased cost on environment controlling facilities	1. Minimize the impacts of rising temperature and periodic scarcity of water on energy, industry and transportation	A. Improvement of watershed management B. Capacity development of storage facilities C. Initiating research studies to assess climate impacts D. Strengthening the monitoring of climate impacts E. Promote efficient practices of water management and use

• **Regular incidents of intense rainfall** • **Increased frequency and severity of floods** • **Increased frequency cyclones and high winds**	• Rapid siltation of hydro power reservoirs • Unfavorable conditions for transportation • Damage to transport infrastructure • Damage to energy and industrial facilities	• Rapid decrease in the capacity of hydropower reservoirs • Disturbances to road, sea and air transportation • Increased congestion and travel time in transportation • Increased risk of accidents • Damages to energy and industrial facilities	• Decline in hydro power generation capacity • Increased cost of transportation • Increased maintenance and rehabilitation cost of transportation infrastructure	2. Minimize the impacts of extreme weather events on energy, industry and transportation	A. Strengthening the monitoring of climate impacts B. Establishment of an efficient climate information and communication system C. Improvement of disaster risk preparedness and management D. Capacity development of storage facilities
• **Inundation of low-lying areas**	• Vulnerability of industries based on coastal areas: e.g. salt, coir and coconut-based industries, mineral sands, boat building industries • Risk of damage on coastal infrastructure: e.g. roads, railways, transmission lines • Long-term risk of submergence of infrastructure and production facilities: energy, transportation and industry	• Decline of coastal industries • Damage to transport infrastructure in coastal areas • Damage to energy infrastructure: transmission • Loss of infrastructure, production and generation facilities	• Loss of income from coastal industries • Increased cost of rehabilitation and maintenance • Cost of new infrastructure • Cost of relocation of industries	3. Minimize the impacts of sea level rise on energy, transportation and industrial facilities	A. Strengthening the monitoring of climate impacts B. Improve salinity protection measures in coastal areas

Table A-10: Time plan and budget – Food Security

Adaptation need	Adaptation option	Action	Time (years)										Proposed budget (Rs. Millions)
			1	2	3	4	5	6	7	8	9	10	
Enhance the resilience of crops, animals, fish and agro-ecosystems against heat and water stress	Germplasm improvement	Screen existing varieties/breeds for heat and water stress.											20
		Develop tolerant varieties (paddy, OFC, horticulture)											20
		Develop heat tolerant breeds (livestock)											20
	Improvement of farm water management	Reduce field-level irrigation water losses											15
		Promote micro-irrigation techniques											15
		Develop water efficient farming methods											15
		Promote on-farm rainwater harvesting											15
	Promotion of resource efficient farming systems	Improve cropping systems and conservation farming practices											8
		Improve nursery protection											8
		Introduce flower induce techniques in fruits											10
		Increase the use organic matter to improve soil quality(Integrated plan nutrient management)											8
		Promote low-water demanding crops and varieties and crop diversifications											8
		Promote the intensive management of livestock											8
	Sectoral Capacity development	Develop research institutes' capacity for conducting research on tolerant varieties and water efficient farming methods.											100
Minimize the risk of crop and health damage due to biological agents	Germplasm improvement	Screen existing varieties/breeds for pest and disease resistance.											20
		Develop pest resistant varieties (paddy, OFC, horticulture)											20
		Develop disease resistant breeds (livestock and poultry)											20

	Strengthening of supporting facilities	Strengthen vaccination programmes	15
		Develop pest forecasting system	20
		Conduct research on parasites and diseases	20
		Promote crop clinics	10
	Promotion of best practices	Promote integrated pest management	10
Minimize the impact on food security due to erratic changes in precipitation	Establishment of an efficient climate information management and communication system	Develop a system for timely issuing of seasonal and medium -term weather forecasts	30
		Adjust cropping calendars according to the seasonal climate forecasts	5
	Improvement of pasture and fodder management	Diversify into livestock feeds other than naturally grown pasture	5
		Promote silage and hey production	5
		Promote techniques of fodder production and conservation	5
Enhance the resilience of crops, animals, fish and agro-ecosystems to extreme weather events	Germplasm improvement	Screen existing varieties for tolerance to extreme events	20
		Develop tolerant varieties (paddy) – drought, flood	20
		Develop tolerant verities (OFC and horticulture) for moisture stress (deficit and excess)	10
	Establishment of an efficient climate information management and communication system	Develop a system for timely issuing of short-term weather forecasts	30
		Strengthen the early warning systems	20
		Strengthen fishing Vessel monitoring and tracking system	100
		Develop mobile phone based communication systems	30
		Develop safety plans and promote use of safety equipment	15
	Improvement of disaster risk	Identify and collect information on areas most vulnerable to flood and drought hazards	20

	preparedness and management	Identify food storage capacities in vulnerable areas	8
		Develop buffer stocks and maintain them regularly	30
Minimize the impacts of sea level rise on agriculture in coastal zone	Germplasm improvement	Screen existing varieties for tolerance to salinity	20
		Develop salinity/alkalinity tolerant varieties (paddy)	20
	Strengthening the monitoring of climate impacts	Monitor regularly the development of salinity/ alkalinity levels	15
		Strengthen the sea water depends structures to control sea water intrusions to coastal paddy lands	30
	Exploring alternatives	Convert severely affected paddy lands for other uses (e.g. brackish water aquaculture)	10
Assess the changes in oceanic environment and impacts on livelihoods and food security	Initiating research studies to assess climate impacts	Assess long-term structural changes oceanic habitats and composition of species	5
		Assess climate change impacts on lagoon and coastal fisheries	20
		Assess climate change impacts on reef fish stock	20
	Strengthening the monitoring of climate impacts	Initiate long term monitoring of essential bio-physical parameters (National monitoring programme)	20
Assess the impacts of rising atmospheric CO_2 on productivity crops and weed populations	Initiating research studies to assess climate impacts	Conduct research studies on impact of increased CO_2 on agriculture Productivity of crops Weed populations	50

Table A-11: Time plan and budget – Water resources

Adaptation need	Adaptation option	Action	Time (years)										Proposed budget (Rs. Millions)
			1	2	3	4	5	6	7	8	9	10	
Enhance the resilience of systems for water resources, management and use to overcome the scarcities caused by climate change impacts	Improvement of watershed management	Identify and map critical watersheds											20
		Develop and implement watershed management plans for critical upper watersheds											100
		Incorporate water safety plans to all watershed areas											20
		Increase the canopy cover in catchment areas											30
		Promote conservation farming methods in reservoir catchments											10
		Launch participatory cascade management programmes in selected village tank catchments											20
		Incorporate effect of climate change for the future water resources development plans											20
	Capacity development of water storage facilities	Assess the current facilities and storage options in connection to future projections of climate change											50
		Evaluate future options for enhancement of storage facilitates including ground water											50
		Develop a road map and investment plan for efficient utilization of existing and future storage options											5
		Assess, regularize and preserve ground water resources at local level and utilize effectively											15
	Initiating research studies to assess climate change impacts	Assess, short-, medium- and long-term impacts of climate change on water resources and management systems in the country											10
		Screen current practices of water management for climate resilience and identify ways to improve them											5
		Explore climate resilient indigenous practices of water sector operation management and identify ways to integrate them into modern practices											~~10~~

	Strengthening the monitoring of climate change impacts	Initiate a long term monitoring program on essential bio-physical parameters (National monitoring programme)	30
	Promote efficient practices of water management and use	Promote efficient domestic water use practices	20
		Increase the efficiency of irrigation water use and reduce losses	40
		Improve maintenance of existing reservoirs	20
		Promote wastewater recycling for industrial and aqua culture water uses	20
Ensure the safety of water management facilities and minimize disturbances to supply due to extreme weather events	Strengthening the monitoring of climate change impacts	Assess the capacity of existing hydro-meteorological information facilities	5
		Implement necessary improvements ~~to~~ and strengthen accordingly	20
	Establishment of an efficient climate information and communication system	Develop a system for timely issuing of short-term weather forecasts	30
		Strengthen the early warning systems	30
		Assess the traditional knowledge of weather forecasting and integrate them for better forecasts of water availability.	10
		Develop network based (mobile phone or GSM) communication systems	50
		Improve the existing system for timely issuing short term weather forecast and long term (climate) forecast	25
	Improvement of disaster risk preparedness and management	Identify,map and collect other information on areas most vulnerable to flood , droughts and landslides hazards	50
		Develop disaster (flood, drought, landslides) risk management plans for vulnerable areas	10
		Establish necessary facilities for improvement of drainage in susceptible areas	20
		Develop dam safety plans and promote use of safety measures and equipment	10

	Capacity development of storage facilities	Design rational strategies to harness excess water in storage facilities (interbrain, intra-basins and trans-basin approaches).											20
Minimize the impacts of sea level rise on water resources and management of coastal areas and wet lands	Strengthening the monitoring of sea level rise	Monitor the development of salinity levels regularly											20
	Improve salt water intrusion protection measures in coastal areas and wetland	Identify vulnerable areas for saltwater intrusion and develop maps											10
		Strengthen the salinity exclusion structures to control sea water intrusions											50
		Design and construct salinity barriers to protect fresh water resources and agriculture lands											50
		Establish desalinization facilities in affected/vulnerable areas											50

Table A-12: Time plan and budget – Coastal and marine sector

Adaptation need	Adaptation option	Actions	Time (years)										Proposed budget (Rs. Millions)
			1	2	3	4	5	6	7	8	9	10	
Strengthen the coastal zone management to face the impacts of sea level rise	Initiating research studies to assess impacts of sea level rise	Study impacts of sea level rise on coastal habitats over short-medium- and long-term horizons											50
		Study erosion trends and identify appropriate protection measures											20
		Conduct research studies on coastal water quality and hydro dynamics in relation to climate change impacts											50
		Establish regional collaborations on research and monitoring											8
	Establishment of a sea level rise monitoring system	Identify critical shore line parameters for regular monitoring											8
		Implement continuous monitoring of shore line changes											100
		Prepare maps on low-lying areas vulnerable to inundation											20
		Prepare a data base on existing coastal habitats											15
		Promote participation of coastal communities in monitoring sea level rise											10
		Establishment of the mean sea level											50
	Strengthening the coastal protection and management	Develop shoreline management plan including M & E programme											10
		Update CZMP to ensure greater concern over climate change impacts											50
		Prepare SMA (Special Management Area) plans for critical & vulnerable areas											20
		Revise set back limits considering sea level rise											10

		Undertake physical protection measures in critical areas											2000
	Participatory management of sensitive coastal habitats	Conduct awareness programs on sea level rise and to empower coastal communities to face climate change impacts											15
		Prepare and implement participatory management plans for the conservation and rehabilitation of sensitive coastal habitats with the collaboration of local communities and CSOs											200
Enhance the resilience of coastal ecosystems against increased extreme events	Improvement of disaster risk preparedness and management	Identify, collect information and prepare maps on coastal areas vulnerable to extreme events											20
		Prepare emergency response/contingency plans and guidelines for vulnerable areas											20
		Establish physical protection measures in critical areas											50
		declaration of affected areas											10

Table A-13: Time plan and budget – Health

Adaptation need	Adaptation option	Actions	Time (years)										Proposed budget (Rs. Millions)
			1	2	3	4	5	6	7	8	9	10	
Assess and prepare for the increased health risks due to climate-induced vector bone and pathogenic diseases	Conducting research studies to assess the risk of climate-induced diseases	Conduct research studies on impact of climate change on prevalence and spread of diseases											30
		Assess critical factors for controlling climate-induced disease incidents											10
		Identify plausible strategies for management of climate-induced disease incidents											10
	Strengthening the surveillance and monitoring of climate- induced diseases	Establish a surveillance program for detection and monitoring of climate-induced diseases											15
		Prepare vulnerability maps on climate related health hazards											8
		Establish a mechanism for sharing meteorological , clinical and entomological information											10
	Capacity development for managing climate-induced disease incidents	Strengthen the alertness of health system against climate-induced disease incidents											20
		Launch an awareness programme on climate and health risks for Health care workers and public											5
		Develop/review guidelines for management of climate-induced disease incidents											5
		Develop research institutes' capacity for conducting research on climate change and health issues-including multidisciplinary collaborative researches											30
Minimize the health hazards associated with increased incidence of extreme events	Establishing an information and communication system on extreme events	Strengthen early warning systems of extreme events											30
		Strengthen the mechanism for sharing information between disaster management and health management agencies											15
	Improvement of disaster risk	Develop disaster risk preparedness guidelines for health care workers in vulnerable areas											10

	preparedness of health related agencies and workers	Increase the knowledge and awareness on health impacts of extreme events among health care workers (e.g. MOH, PHI)											10
		Improve the coordination between disaster management and health management agencies											15
Assess and prepare for health risks caused by concentration of climate altering pollutants	Conducting research studies to assess health impacts of climate altering pollutants	Conduct research studies on climate altering pollutants / O2 availability , their temporal variations and health impacts											30
		Update and assess treatment procedures and diagnostic tools											10
	Improvement of monitoring of climate altering pollutants	Establish air quality monitoring facilities in strategic locations											20
		Review and improve monitoring standards of pollutants to keep up with world standards											20
		Establish a mechanism for consulting health sector on matters concerning EPLs											20
		Establish pollutions/dispersion transport forecasting system (computer numerical modeling)											10
	Capacity development for managing health impacts of climate altering pollutants	Strengthen respiratory disease control programme											15
		Develop guidelines for controlling exposure											10
		Increase public awareness on health impacts of air pollution											10
		Train health workers on environmental health and safety											8
		Develop a mechanism to disseminate air pollution level online to the general public, high risk areas											10
Assess the impact on health due to increased heat and thermal stress	Conducting research studies to assess health impacts of heat/thermal stress	Conduct research studies on heat/thermal stress on human health											20
		Identify and assess Diagnostic tools and treatment procedures											15
		Increase public awareness on health risks of heat /thermal stress											10

Table A-14: Time plan and budget – Human settlements and infrastructure

Adaptation need	Adaptation option	Actions	Time (years)										Proposed budget (Rs. Millions)
			1	2	3	4	5	6	7	8	9	10	
Enhance the resilience of human settlements and infrastructure against heat and water stress	Improvement and promotion of building designs for enhanced climate resilience	Mainstream climate resilience in physical and urban planning											8
		Promote climate resilient building designs											10
		Promote use of alternative materials											10
		Develop/review appropriate sector specific building standards and guidelines for urban, rural and estate sectors											8
		Promote planning the human settlement schemes so as to minimize the adverse effect (and promote) on localized and regional water resources											10
		Provide standardization of equipment such as A/C and refrigerators so they emit less GHG's											15
	Revision of procedures and guidelines	Revise building approval systems to ensure climate resilience											5
	Initiating research studies to assess climate impacts	Conduct research studies on climate resilient building designs, green buildings and alternative materials											25
	Sectoral Capacity development	Conduct training programs for industry stakeholders											15
Minimize the impacts on human settlements and infrastructure due to erratic changes in precipitation	Enhance the capacity of infrastructure in urban settlements	Extend the capacity of drainage and sewerage systems to avoid periodic overcrowding											15
		Rationale use of drainage infrastructure to encourage recharging of ground water systems											15
	Promote water safety and	Promote measures to ensure safety of domestic water for settlements											30

	efficient utilization of surplus water	Promote use of rainwater harvesting systems to collect water in surplus periods to be used in the dry periods											10
Enhance the resilience of human settlements and infrastructure to extreme weather events	Promotion of disaster resilient buildings and construction	Promote disaster resilient buildings (new constructions)											10
		Promote practice of building codes including roofing standards specially in the public buildings											10
	Improvement of disaster risk preparedness and management	Prepare hazard preparedness plans for urban, rural and estate settlements											8
		Revisit existing preparedness plans for climate change											8
		Develop and enforce zoning system based on hazard vulnerability											8
Minimize the impacts of sea level rise on coastal settlements and infrastructure	Increase the resilience of coastal settlements	Promote buildings standards which are specific to the coastal sector											10
	Strengthening the monitoring of sea level rise	Regular monitoring of sea level rise											20
		Prepare maps on low-lying areas vulnerable to inundation											8
		Demarcate coastal zones vulnerable to inundation											10
		Develop guidelines for human settlements and infrastructure in vulnerable zones											10

Table A-15: Time plan and budget – Ecosystems and biodiversity

Adaptation need	Adaptation option	Actions	Time (years)										Proposed budget (Rs. Millions)
			1	2	3	4	5	6	7	8	9	10	
Enhance the resilience of natural and agro ecosystems against the impacts of climate change impacts	Initiating research studies to assess climate impacts	Conduct research studies on climate change impacts on ecosystems and biodiversity											100
		Life cycle studies: this should cover things such as changes in the sex ratios											50
	Extend the existing biodiversity protection interventions to cover climate change impacts	Prepare adaptive management programmes for climate sensitive ecosystems											50
		Protect marshes/flood retention areas vulnerable to thermal stress											20
		Develop a comprehensive plan for mitigating wild/forest fire incidents											20
		Prepare recovery plans for highly threatened ecosystems are and species											50
	Strengthening the monitoring of climate impacts	Establish a comprehensive programme (GIS mapping) to monitor climate change impacts on key natural ecosystems and biodiversity											50
		Establish permanent monitoring plots for research on natural bio-diversity											30
	Enhance the participation of local communities in monitoring, conservation and management of biodiversity	Conduct awareness programs for local communities on impacts on climate change local biodiversity and ecosystems in vulnerable areas											20
		Organize local CBOs for monitoring changes in local ecosystems and bio diversity											10
		Ensure participation of local communities in adaptive management programmes											10
		Increase employment opportunities in local communities for conservation activities											

	Promotion of traditional methods of biodiversity conservation for increased resilience in agro-ecosystems	Study and Identify traditional methods of biodiversity management in agro ecosystems	10
		Identify and promote different agro-biodiversity models suitable for different agro-climatic zones	20
	Sectoral Capacity development	Develop research institutes' capacity for conducting research on climate change impacts on ecosystems and biodiversity	50
		Strengthen the existing capacities for genetic preservation of fauna and flora.	50
Enhance the resilience of natural and agro ecosystems against extreme weather events	Improvement of disaster risk preparedness and management	Strengthen the early warning systems	50
		Identify and collect information on ecosystems and geographical locations most vulnerable to flood and drought hazards	20
		Prepare emergency response/contingency plans and guidelines for vulnerable areas	10
Minimize the impacts of sea level rise on coastal bio-diversity and ecosystem services	Initiating research studies to assess climate impacts	Conduct research studies on	30
	Strengthening the monitoring of climate impacts	Monitor regularly the development of salinity levels	20
Assess the changes in oceanic environment and impacts on livelihoods and food security	Initiating research studies to assess climate impacts	Assess changes in oceanic habitats and composition of species due to impacts of climate change on oceanic environment	20
	Strengthening the monitoring of climate impacts	Initiate long term monitoring of essential bio-physical parameters (National monitoring programme)	20

Assess the impacts of rising atmospheric CO_2 on biomass production of natural vegetation and spread of invasive alien species	Initiating research studies to assess climate impacts	Conduct research studies on impact of increased CO_2 on natural ecosystems and biodiversity											50

Table A-16: Time plan and budget – Tourism and recreation

Adaptation need	Adaptation option	Actions	Time (years)										Proposed budget (Rs. Millions)
			1	2	3	4	5	6	7	8	9	10	
Adjustment of tourism and recreation industry to altered conditions of the destination	Initiating research studies to assess climate impacts	Conduct research studies on climate change impacts on tourism and recreation											30
	Operational adjustments in the industry	Diversify the tourism products to meet the changing conditions											15
		Develop collaborative plans with key stakeholders to adjust tourism operations in different locations											10
		Increase the awareness of tour industry operators on climate change and its impacts											8
		Improve the climate preparedness element in organizing and executing tour operations											8
		Identify tourism facilities in vulnerable areas (e.g. low-lying beaches; disaster prone areas) and make arrangements to improve the resilience											10
	Changing of promotional strategies	Assess the current promotional strategies with connection to emerging scenarios of climate change											5
		Adjust the promotions to suit the different climate scenarios											10
Increase the preparedness of tourism and recreation operations to extreme weather conditions	Improvement of emergency risk preparedness and management	Prepare guidelines on managing emergencies in tour operations											8
		Train tour operators on emergency management strategies											10
		Design tourism infrastructure to meet the safety needs of operations											50
		Develop system's capacity for smooth switching to alternate plans											20
		Establish emergency communication channels for tourists and operators											20

	Establishment of an efficient climate information management and communication system	Develop a system for timely issuing of short-term weather forecasts											30
		Strengthen the early warning systems											50

Table A-17: Time plan and budget – Export agriculture sector

Adaptation need	Adaptation option	Actions	Time (years)										Proposed budget (Rs. Millions)
			1	2	3	4	5	6	7	8	9	10	
Enhance the resilience of crops, animals, fish and agro-ecosystems against heat and water stress	Germplasm improvement	Screen existing cultivars/clones for heat, water stress, flooding and resistance for biotic stress (pests and diseases).											25
		Introduce new cultivars /clones tolerant to heat and drought											85
		Develop grafted/budded plants with drought resistance properties											50
	Improvement of farm and nursery management practices	Improve the management of shade trees as a climate change adaptation measure											60
		Promote suitable operational and management techniques											30
		Develop improved cropping system models for vulnerable areas/lands											30
		Promote improved nursery and plant management practices											50
	Initiating research studies to assess climate impacts	Conduct research studies on climate impacts on crop physiology, resistant cultivars and cropping systems											150
	Sector capacity development	Develop research institutes' capacity for conducting research on tolerant cultivars/clones											150
		Develop facilities necessary to undertake controlled environment research											200
Minimize the risk of crop and health damage due to biological agents	Germplasm improvement	Screen existing cultivars/clones for pest and disease resistance.											50
		Develop pest and diseases-resistant varieties											50
	Improvement of farm and nursery management practices	Develop recommendations on best practices of pest and disease management											10
	Monitoring and surveillance of	Establish a surveillance programme for early detection of new diseases and pests											10

	pest and disease	Develop a system forecasting risks of pest and diseases	30
Minimize the impact on food security due to erratic changes in precipitation	Establishment of an efficient climate information management and communication system	Develop a system for timely issuing of seasonal and short-term weather forecasts	30
		Adjust calendar of operations with seasonal weather forecasts	10
	Improvements in cropping systems	Promote sustainable cropping system practices for increasing the resilience of plantations and trees	15
Enhance the resilience of crops, animals, fish and agro-ecosystems to extreme weather events	Establishment of an efficient climate information management and communication system	Develop a system for timely issuing of short-term weather forecasts	30
		Strengthen the early warning systems	30
	Improvement of disaster risk preparedness and management	Identify and collect information on areas most vulnerable to flood and drought hazards	15
		Prepare hazard vulnerability maps for all crops	10
		Develop guidelines for management of extreme events in vulnerable areas	10
Minimize the impacts of sea level rise on agriculture in coastal zone	Strengthening the monitoring of climate impacts	Monitor regularly the development of salinity levels	15
	Development of protection structures	construct salinity exclusion structures and salinity barriers to control sea water intrusions to agricultural lands	30

Table A-18: Time plan and budget – Industry, energy and transportation

Adaptation need	Adaptation option	Actions	Time (years)										Proposed budget (Rs. Millions)
			1	2	3	4	5	6	7	8	9	10	
Minimize the impacts of rising temperature and periodic scarcity of water on energy, industry and transportation	System improvements and diversification of energy generation industry and transportation	Minimize the fluctuation of hydro power generation potential through improvements in system management											50
		Explore alternatives for maximizing the use of hydro power facilities: e.g. pump storage											20
		Improve the efficiency of transmission and distribution systems to minimize losses											100
		Diversify the energy mix with increased share of renewable energy (TNA recommendations)											100
		Factor in climate change into long-term generation plans											30
	Supply chain improvements in agro-based raw materials	Diversify the supply sources of climate sensitive raw materials											30
		Develop forward contract markets for agro-based raw materials											50
		Introduce innovative risk transfer instruments											100
	Initiating research studies to assess climate change impacts	Explore and assess the potential for developing (or retrofitting) pump storage options for hydro power generation facilities											30
		Conduct research studies on climate sensitive agro-based raw materials and options to ensure stable supply											30
Minimize the impacts of extreme weather events on energy, industry and transportation	Improvement of the climate resilience and disaster risk preparedness of industry, energy and transportation	Assess the impacts of projected changes and extreme weather scenarios on transportation systems											10
		Assess vulnerable and hazard prone areas/roads and prepare maps											10
		Identification of climate resilient improvements in transport planning, infrastructure development and implementation of plans											10
		Develop guidelines for improve the resilience of transportation system for extreme weather situations											10
		Create awareness on climate risks in transportation to commuters, drivers and transport operators											10

		Establish an early warning and hazard communication systems for commuters and drivers (mobile phones, navigation systems, radio channels)	50
	Development of climate change resilient infrastructure and production facilities	Promote climate change proof infrastructure and building design practices	50
		Identify critically vulnerable energy sources and industrial facilities in hazard prone areas	10
		Assess suitable interventions to strengthen climate resilience	10
	Improvement of disaster risk preparedness and management	Identify vulnerable areas for climate-induced disaster risks and prepare maps	10
		Develop a system for timely issuing of short-term weather forecasts	8
		Establish an early warning system of disasters to managers of energy, transport and industry	20
Minimize the impacts of sea level rise on energy, transportation and industrial facilities	Strengthening the monitoring of sea level rise	Regular monitoring of sea level rise	10
		Prepare maps on low-lying areas vulnerable to inundation	10
		Demarcate coastal zones vulnerable to inundation	10
		Develop guidelines for economic activities in vulnerable areas	10
	Increasing the preparedness for sea level rise	Identify critically vulnerable energy, transportation and industrial facilities in vulnerable areas due to inundation	10
		Develop contingency plans to gradual relocation and development of alternatives	10
	Initiating research studies to assess climate change impacts	Conduct research studies and assess the vulnerability of industries located in coastal areas (e.g. salt, coir and coconut-based industries, mineral sands, boat building industries)	30

Table A-19: Time plan and budget – Cross-cutting needs of adaptation

Cross-cutting area	Action	Time (years)										Proposed budget (Rs. Millions)
		1	2	3	4	5	6	7	8	9	10	
Policy, legal and governance	Undertake a review of relevant macro and sectoral policies, ordinances acts and statutory procedures to identify options for mainstreaming climate change adaptation activities in Sri Lanka											8
	Develop policy recommendations necessary for ensuring climate change vulnerability issues are addressed in all development /management projects											15
	Carry out a policy study to explore the possibilities for application of market-based instruments to motivate adaptive actions and identify and assess feasibility of introducing innovative risk transfer tools (e.g. insurance schemes)											10
Institutional and coordination	Restructure and strengthen the Climate Change Secretariat as the National Focal Point (NFP) for implementation of NAP											100
	Establish an sustain a suitable institutional mechanism for implementation of sectoral and cross-cutting actions of NAP											60
	Organize a *Forum of Civil Society Organizations* (FCSO), a group of partner agencies, at national, provincial and district levels to support the implementation and coordination of community-based sectoral and cross-cutting interventions proposed by NAP											45
International cooperation and partnerships	Develop an inventory of international climate donors, funding schemes, training providers, training programs, research agencies/consortiums and events (conferences, seminars etc.) for the benefit of local stakeholders of adaptation.											5
	Establish a network of sectoral and national agencies, CSO partners, research institutes, think tanks and academics to approach international service providers through the facilitation support of the National Focal Point for funding support, technical assistance or training necessary for adaptation actions identified in NAP or supportive programs developed to achieve NAP objectives											10
	Identify a group of sectoral and national level representatives from government organizations, CSOs and private sector to create a pool of climate negotiators											10

Resource mobilization	Create a *National Adaptation Fund* with the collaboration of the Ministry of Finance to support the implementation of NAP actions and supportive programs	20
	Develop a 'fast track' mechanism for approving requests for donor funding for climate adaptation projects through the collaboration of the National Focal Point and the External Resources Department	2
	Negotiate a private channel of funding with the corporate sector for directing a share of CSR allocations for climate adaptation projects. If possible create a trust fund for channeling and pooling of funds partnered by the Finance Ministry and corporate sector members	2
Research and development	Establish national level controlled environment research facilities in selected institutes for facilitation of multi-disciplinary research	100
	Establish a national network of agencies and universities for carrying out research & development on climate adaptation, promotion of coordination among research institutes and information dissemination.	20
	Organize an annual multi-disciplinary research symposium on climate change adaptation with international participation	30
	Develop a coordinated multi-disciplinary small research grant program on thematic areas relating to climate change adaptation facilitated by the National Focal Point and managed by the national research support agencies (e.g. NSF, NRC, CARP)	100
	Establish a funding facility to undertake advanced studies on selected core areas of nationally important research	1000
	Establish a common repository of scientific and awareness materials on climate change adaptation.	30
Technology transfer and standards	Identify international technology transfer service providers and technology developers, and negotiate with them to establish technology and skills transfer opportunities for local researchers, trainers, experts, technology users and students.	10
	Organize national level technology transfer events and programs (e.g. Dissemination programs, exhibitions, training programs and demonstrations) to transfer technology/knowledge from developers and experts to technology users.	20

Building adaptive capacity of communities	Develop a small grant facility to provide seed funding for community-level programs helpful for achieving NAP objectives to be supported by the National Climate Adaptation Fund and jointly coordinated by *CSO Forum* and the National Focal Point	100
	Launch a program for gathering, compiling and documentation of traditional local knowledge on climate adaptation and indigenous forecasting as a partnership program of academics, CSO members and researchers.	50
	Initiate an island wide program for identification and vulnerability assessment of religious, cultural and archaeological assets threatened by climate change implemented by experts on archaeology and culture, religious organizations, CSO members and local communities.	50
Education, training and awareness	Conduct training programs for government officers, CSO members, and private sector employees on climate change adaptation which includes integrating climate change components to existing training programmes	30
	Incorporate and further strengthen climate change knowledge in formal education	25
	Establish a media space (including social media) for climate change impacts and adaptation to enhance public awareness	15
Climate information management	Establish a *National Task Force on Climate Information Products* to strengthen current efforts for developing seasonal and sub-season climate forecasts	50
	Identify capacity development needs of the Department of Meteorology and provide necessary support to strengthen the capacity for offering reliable weather, sub-seasonal and seasonal forecasts	100
	Undertake a study on short and medium range indigenous weather forecasting knowledge and identify ways to incorporate it into a national climate risk surveillance program	20
	Establish a national research program on climate modeling for long-term climate projections	50
Climate-induced disaster risk reduction	Assess the disaster risk reduction needs of sectoral Climate Adaptation Cells (identified in NAP) and mainstream the implementation of them with ongoing programs of disaster risk management	10

List of Participants in the Stakeholder Consultation Workshops

Food Security			
	Name	**Designation**	**Institute**
1	Dr. W.M.A.D.B. Wickramasinghe	Director	Department of Agriculture
2	Mr. S.A.M. Azmy	Head / ESD	National Aquatic Resources Research and Development Agency (NARA)
3	Mr. J.K.M. Chandrasiri	Additional Director	Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI)
4	Dr. Niroshan Gamage	Deputy Director/ Livestock Planning	Ministry of Livestock and Rural Community Development
5	Mr. G.D.J. Nawaratne	Senior Engineer Assistant	Agrarian Development Department, Head Office
6	Ms. L.G.K Isuruni	Assistant Director, Industry	Department of Fisheries
7	Dr. G.G.C. Premalal	Research Officer	Veterinary Research Institute
8	Mr. A.A.S.P. Adikari	Development Officer	Ministry of Livestock and Rural Community Development
9	Dr. (Mrs) S.M. Wijesundara	Food Sector Expert	Gamunupura, Kotalawala, Kaduwela
10	Dr. R.D.S. Jayathunga	Director (Climate Change)	Ministry of Mahaweli Development and Environment
11	Ms. H.N.K.T Dulani	Assistant Director, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
12	Mr. Ranjith Rajapakshe	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
13	Ms. K.K.S. Priyanthi	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
14	Ms. Nilmini Ranasinghe	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment

Water Resources			
	Name	**Designation**	**Institute**
1	Mr. S.G.R.Rajkumar	Deputy General Manager (Development)	National Water Supply & Drainage Board
2	Dr. H. Manthrithilaka	Head, Sri Lanka Development Initiative	International Water Management Institute (IWMI)
3	Ms. Nishadi Eriyagama	Water Resource Engineer	International Water Management Institute (IWMI)
4	Ms. Priyangani Gunathilaka	Deputy Director	Central Environmental Authority
5	Mr. G.R.R Karunarathne	Deputy General Manager, Research & Development	Water Resource Board
6	Ms. Janaki Migastenna	Deputy Director (Irrigation & Water Mgt.)	Department of Irrigation
7	Mr. K.P.M Dissanayake	Monitoring Officer	Department of Irrigation
8	Mr. Madduma Bandara	Deputy Director General	Mahawali Authority of Sri Lanka
9	Ms. E.L.S. Nilmini	Environment Officer	Mahawali Authority of Sri Lanka
10	Mr. Prabath Witharana	Director (NRM)	Agrarian Development Department
11	Ms. Ramya Wijesekara	Engineer (Research)	Industrial Technology Institute
12	Dr. R.D.S. Jayathunga	Director, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
13	Ms. H.N.K.T. Dulani	Assistant Director, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
14	Mr. Ranjith Rajapakshe	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
15	Ms. K.K.S. Priyanthi	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
16	Ms. Nilmini Ranasinghe	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
17	Mr. J. Ranjith Wimalasiri	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
18	Mr. Upul Premalal	Research Assistant, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
19	Ms. Dharshika Pathirana	Development Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment

Coastal and Marine Sector			
	Name	**Designation**	**Institute**
1	Ms. Mangala Wickramanayaka	Director General	Coast Conservation and Coastal Resources Management Department
2	Dr. Champa Amarasiri	Consultant	Ocean University of Sri Lanka
3	Ms. L.U.N. Sumanasekera	Director (Agricultural Technology)	Ministry of Agriculture
4	Mr. M.G. Ajith Pushpakumara	Deputy Director	Ministry of Agriculture
5	Dr. Terney Predeep Kumara	Director General	Marine Environment Protection Authority
6	Prof. E.I.L. Silva	Chief Executive Officer	Water Resources Science and Technology (WRST)
7	Ms. L.G.R. Isurani	Additional Director (Industry)	Department of Fisheries and Aquatic Resources
8	Mr. B.A.P. Kapila	Additional Director	Ministry of Fisheries and Aquatic Resources Development
9	Mr. D. Hettiarachchi	Director (Env. & Landscape)	Urban Development Authority
10	Mr. Arjun Rajasuriya	Coordinator, Marine & Coastal	International Union for Conservation of Nature (I UCN)

Health			
	Name	**Designation**	**Institute**
1	Dr. Ruwan Wijayamuni	Chief Medical Officer - City of Colombo	Public Health Department, Colombo Municipal Council
2	Prof. W.L. Sumathipala	Chairman	National Science Foundation
3	Dr. Paba Palihawadana	Chief Epidemiologist	Epidemiology Unit, MoH
4	Ms. Subhashini Kulathunga Mudali	Director, Development	Ministry of Health & Indigenous Medicine
5	Dr. Hasitha Tissera	Director, Dengue Control	National Dengue Control Unit – MOH
6	Dr. Gogumpriya Ranasinghe	Deputy Director (Medical)	Ministry of Health & Indigenous Medicine
7	Dr. Inoka Suraweera	Consultant Community Physician, ELOH	Ministry of Health and Indigenous Medicine
8	Dr. K.M. Seneviratne	Regional Epidemiologist, RDHS Office, Nuwaraeliya	Ministry of Health and Indigenous Medicine

9	Dr. Nimal Gamagedara	Consultant Community Physician, Provincial Directorate of Health Services - Uva	Ministry of Health and Indigenous Medicine
10	Dr. N.P. Sumanaweera	National Consultant, World Heritage Organization (Emergency Health Unit)	Ministry of Health and Indigenous Medicine
11	Dr. Asanga Ranasinghe	MO/Prov. Renal Diseases Prevention & Research Unit, PDHS Office, NCP	Ministry of Health and Indigenous Medicine
12	Dr. Nirupa Pallewatte	Consultant Community Physician, National Programme for Tuberculosis Control & Chest Disease	Ministry of Health and Indigenous Medicine
13	Dr. Dewanee Ranaweera	Consultant Community Physician, Anti Malaria Campaign	Ministry of Health and Indigenous Medicine
14	Dr. H.M.P. Hewawitharana	Entomologist, Anti Malaria Campaign	Ministry of Health and Indigenous Medicine
15	Dr. Ananda Jayalal	Director, E&OH	Ministry of Health and Indigenous Medicine
16	Ms. Sujeewa Fernando	Environment Management Officer	Ministry of Health and Indigenous Medicine
17	Mr. M.S.D. Munasinghe	Deputy Director	Central Environmental Authority
18	Ms. Hiranthi Jansz	Assistant Director	Central Environmental Authority
19	Dr. R.D.S. Jayathunga	Director (Climate Change)	Ministry of Mahaweli Development and Environment
20	Mrs.H.N.K.T. Dulani	Assistant Director, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
21	Mr. Ranjith Rajapaksha	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
22	Ms. K.K.S. Priyanthi	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
23	Ms. Nilmini Ranasinghe	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
24	Mr. J. Ranjith Wimalasiri	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
25	Mr. Upul Premalal	Research Assistant, Climate Change Secretariat	Ministry of Mahaweli Development and Environment

26	Ms. T.G.W. Thiranagamage	Development Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment

Human Settlements and Infrastructure			
	Name	**Designation**	**Institute**
1	Mr. R.P. Samarakkody	Additional Director General	Disaster Management Center
2	Mr. Nuwan Maduwan Arachchi	Additional Director (PP)	Disaster Management Center
3	Dr. Novil Wijesekera	Medical Officer, Disaster Preparedness & Response Division	Ministry of Health & Indigenous Medicine
4	Mr. D. Hettiarachchi	Director (Environment)	Urban Development Authority
5	Mr. Piyal Ganepola	Deputy Project Manager	UN Habitat
6	Ms. I.S. Weerasooriya	Project Manager	UN Habitat
7	Mr. Tharindu Abhayajeewa	Project Officer	UN Habitat
8	Mr. K.C. Sugathapala	Director, Human Settlement and Planning	National Building Research Organization (NBRO)
9	Prof. P.K.S. Mahanama	Professor, Faculty of Architecture	University of Moratuwa
10	Mr. M.A. Mohomed Piyas	Town Planner	Dept. of National Physical Planning
11	Mr. M.D.R. Prasad	Assistant Director	Ministry of Public Administration, Provincial Council & Local Govt.
12	Mr. A.G.D. L. Karunaratne	Assistant Director (NRM)	Central Environmental Authority
13	Ms. K.A.C. Senaratna	Engineer	Sri Lanka Sustainable Energy Authority
14	Ms. Pornima Kalhari	Engineer	Sri Lanka Sustainable Energy Authority
15	Ms. Sujeewa Fernando	Environment Management Officer	Ministry of Health & Indigenous Medicine
16	Dr. R.D.S. Jayathunga	Director (Climate Change)	Ministry of Mahaweli Development and Environment
17	Mrs. H.N.K.T. Dulani	Assistant Director, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
18	Mr. Ranjith Rajapaksha	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment

19	Ms. K.K.S. Priyanthi	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
20	Ms. Nilmini Ranasinghe	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
21	Mr. J. Ranjith Wimalasiri	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
22	Mr. Upul Premalal	Research Assistant, Climate Change Secretariat	Ministry of Mahaweli Development and Environment

Ecosystems and Biodiversity/Tourism and Recreation			
	Name	**Designation**	**Institute**
1	Ms. Mangala Wickramanayaka	Director General	Coastal Conservation Department
2	Prof. Devaka Weerakoon	Professor	University of Colombo
3	Dr. D.H.P. Peramunagama	Director (Development)	Department of National Botanic Gardens
4	Dr. Athula Gnanapala	Head/Senior Lecturer Department of Tourism Mgt.	Sabaragamuwa University
5	Ms. K.B.C. Pushpalatha	Director (Extension & Training)	National Aquaculture Development Authority (NAQDA)
6	Mrs. Thalatha Ranasinghe	Assistant Manager	Marine Environment Protection Authority
7	Ms. Dammika Malsinghe	Additional Director (Operation)	Department of National Zoological Garden
8	Dr. K. Hettiarachchi	Deputy Director, Plant Genetic Resources Centre	Department of Agriculture
9	Mr. V.A.M. Azmy	Head (ESI)	National Aquatic Resources Research and Development Agency (NARA)
10	Mr. S.P. Vidanage	Programme Coordinator	International Union for Conservation of Nature (IUCN)
11	Mr. Isuru Alawatta	Assistant Conservator of Forest	Forest Department
12	Mr. Leel Randeni	Environment Management Officer, Bio Diversity Secretariat	Ministry of Mahaweli Development and Environment

13	Ms. Pradeepa Ranaweera	Program Assistant, Bio Diversity Secretariat	Ministry of Mahaweli Development and Environment
14	S.D. Rajapaksha	Development Officer, Bio Diversity Secretariat	Ministry of Mahaweli Development and Environment
15	Dr. R.D.S. Jayathunga	Director (Climate Change)	Ministry of Mahaweli Development and Environment
16	Ms. H.N.K.T. Dulani	Assistant Director, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
17	Mr. Ranjith Rajapaksha	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
18	Ms. Shyamali Priyanthi	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
19	Ms. R.M.N.P. Ranasinghe	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
20	Ms. Iresha Rajapakasa	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
21	Ms. Hasula Wickramasinghe	Programme Assistant, Climate Change Secretariat	Ministry of Mahaweli Development and Environment

Export Agriculture Sector			
	Name	**Designation**	**Institute**
1	Dr. A. P. Heenkenda	Additional Director General	Departmentt of Export Agriculture
2	Dr. H.A. Sumanasena	Director	Department of Export Agriculture
3	Mr. Darshana Perera	Deputy Director	Sri Lanka Export Development Board
4	Ms. Gayani Wijayathilaka	Assistant Director	Sri Lanka Export Development Board
5	Mr. L.M.J.R. Wijayawardane	Research Officer	Sugarcane Research Institute
6	Dr. C.S. Ranasinghe	Head/ Plant Physiology Division	Coconut Research Institute
7	Ms. D.N. Ambepitiya	Additional Director (Planning)	Ministry of Irrigation and Agriculture
8	Mr. N.S. Jayalath	Assistant General Manager	Coconut Cultivation Board
9	Mr. G.R. Bandula Kumara	Deputy General Manager	Coconut Cultivation Board
10	Mr. S.S.B. Rathnayake	Assistant General Manager	Sri Lanka Cashew Crop

11	Dr. V.H.L. Rodrigo	Additional Director	Rubber Research and Development Institute
12	Mr. E.S. Munasinghe	Senior Research Officer	Rubber Research and Development Institute
13	Ms. T.L. Wijerathne	Research Officer	Tea Research Institute
14	Mr. H.I.C. Jayasooriya	Research Officer	Hector Kobbekaduwa Agrarian Research and training Institute (HARTI)
15	Dr. R.D.S. Jayathunga	Director (Climate Change)	Ministry of Mahaweli Development and Environment
16	Ms. H.N.K.T. Dulani	Assistant Director, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
17	Mr. Ranjith Rajapaksha	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
18	Ms. K.K.S. Priyanthi	Environment Management Officer	Ministry of Mahaweli Development and Environment
19	Ms. Nilmini Ranasinghe	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
20	Ms. Ambika Tennakoon	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
21	Mr. Upul Premalal	Research Assistant, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
22	Mr. Dasun Hewapathirana	Research Assistant, Climate Change Secretariat	Ministry of Mahaweli Development and Environment

Industry , Energy and Transport			
	Name	**Designation**	**Institute**
1	Mr. Asitha K Senaviratna	Additional Secretary	Ministry of Industry & Commerce
2	Mr. A.H.S. Wijesinghe	Additional Secretary (Development)	Ministry of Power and Energy
3	Mr. Sena Peiris	Chief executive Officer	National Cleaner Production Centre
4	Mr. S.A.L. Subasinghe	Assistant Director (planning)	Ministry of Transport
5	Mr. S.N. Bentotage	Senior Lecture	University of Moratuwa
6	Mr. Susantha Udugedara	RECP Technologist	National Cleaner Production Centre
7	Mr. S.H.U. De Silva	Director (ESD)	Road Development Authority
8	Mr. Ronald Comebe	Deputy General Manager	Ceylon Electricity Board
9	Mr. P.G. Joseph	Consultant	Sri Lanka Carbon Fund

10	Dr. R.D.S. Jayathunga	Director (Climate Change)	Ministry of Mahaweli Development and Environment
11	Mr. Ranjith Rajapaksha	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
12	Ms .K.K.S. Priyanthi	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
13	Ms. Nilmini Ranasinghe	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
14	Ms. Ambika Tennakoon	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
15	Mr. Upul Premalal	Research Assistant, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
16	Mr. Dasun Hewapathirana	Research Assistant, Climate Change Secretariat	Ministry of Mahaweli Development and Environment

Cross Cutting National Issues of Adaptation			
	Name	**Designation**	**Institute**
1	Mr. Anura Sathurusinghe	Conservator General of Forests	Forest Department
2	Dr. Terney Predeep Kumara	Director General	Marine Environment Protection Authority
3	Mr. S.G.R. Rajkumar	Deputy General Manager (Development)	National Water Supply and Drainage Board
4	Mr. S.A.M. Azmy	Head / ESD	National Aquatic Resources Research and Development Agency (NARA)
5	Ms. Janaki Migastenna	Deputy Director (Irrigation & Water Mgt.)	Department of Irrigation
6	Dr. D.H.P. Peramunagama	Director (Development)	Department of National Botanic Gardens
7	Mr. Nuwan Maduwan Arachchi	Additional Director (PP)	Disaster Management Centre
8	Ms. D.N. Ambepitiya	Additional Director (Planning)	Ministry of Irrigation and Agriculture
9	Ms. T.L. Wijerathne	Research Officer	Tea Research Institute
10	Mr. Darshana Perera	Deputy Director	Sri Lanka Export Development Board
11	Mr. M.A. Mohomed Piyas	Town Planner	Dept. of National Physical Planning
12	Dr. C.S. Ranasinghe	Head/ Plant Physiology Division	Coconut Research Institute

13	Ms. Manjula Wimalasena	Legal Officer	Central Environmental Authority
14	Ms. A.L.S. Nazeema	Director	Ministry of Highways, Higher Education and Investment Promotion
15	Ms. Anoja Herath	Director	Ministry of Irrigation and Agriculture
16	Mr. Sena Peiris	Chief Executive Officer	National Cleaner Production Center
17	Mr. P.G. Joseph	Consultant	Sri Lanka Carbon Fund
18	Dr. (Mrs) S. M. Wijesundara	Food Sector Expert	No. 35B, Second Lane, Gamunupura, Kotalawala, Kaduwela
19	Prof. Buddhi Marambe	Professor, Faculty of Agriculture	University of Peradeniya
20	Mr. Ranga Pallawela	Director	Janathakshan
21	Mr. Hemantha Withanage	Executive Director	Center for Environment Justice
22	Mr. U.R. Wickramaarachchi	Fisheries Inspector	Department of Fisheries and Aquatic Resources
23	Ms. A.K.R. Dilshani	Fisheries Inspector	Department of Fisheries and Aquatic Resources
24	Ms. S.A. Mahaarachchi	Engineer (Research and Design)	Coast Conservation and Coastal Resources Management Department
25	Mr. J.A.V.S. Jayakody	Deputy Director	Road Development Authority
26	Ms. Sukanthy Vairamuthu	Development Officer	Ministry of Social Services, Welfare and Livestock Development
27	Dr. Niroshan Gamage	Deputy Director	Ministry of Social Services, Welfare and Livestock Development
28	Mr. Roshan Salinda	Programme Manager	Green Movement of Sri Lanka

Validation and Finalization Workshop			
	Name	**Designation**	**Institute**
1	Mr. J.K.M. Chandrasiri	Additional Director	Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI)
2	Ms. L.U.N. Sumanasekara	Director Agriculture Technology	Ministry of Agriculture
3	Mr. R.P. Smarakkody	Additional Director General	Disaster Management Center
4	Mr. A.H.S. Wijesinghe	Additional Secretary (Development)	Ministry of Power and Energy
5	Dr. A. P. Heenkenda	Additional Director General	Department of Export Agriculture
6	Ms. Janaki Migastenna	Director (Water Management)	Department of Irrigation

7	Mr. B.A.P. Kapila	Additional Director	Ministry of Fisheries and Aquatic Resources
8	Mr. S.H.U. De Silva	Director (ESD)	Road Development Authority
9	Mr. S.G.R. Rajkumar	Deputy General Manager (Development)	National Water Supply and Drainage Board
10	Mr. Bharatha Ramanayake	Director (Planning)	Ministry of Fisheries and Aquatic Resources Development
11	Dr. Terney Predeep Kumara	General Manager	Marine Environmental Protection Authority
12	Mr. Madduma Bandara	Director (Environment)	Mahaweli Authority of Sri Lanka
13	Mr. A.Z.J. Singarayer	Senior Engineering Assistant	Agrarian Development Department
14	Mr. K. Nanayakkara	Director (Development)	Department of National Botanic Gardens
15	Dr. Inoka Suraeera	Consultant Community Physician	Ministry of Health and Indigenous Medicine
16	Ms. Sujeewa Fernando	Environmental Management Officer	Ministry of Health and Indigenous Medicine
17	Pro. W.L. Sumathipala	Consultant	Ministry of Mahaweli Development and Environment
18	Mr. M.M.M. Aheeyer	Management Officer	International Water Management Institute (IWMI)
19	Mr. A.L. Chandrajith De Silva	Senior Research Officer	Sugarcane Research Institute
20	Mr. S.S.B. Rathnayake	Assistant General Manager	Sri Lanka Cashew Corporation
21	Mr. T.L. Wijerathna	Research Officer	Tea Research Institute
22	Ms. Anusha Maduwanthi	Town Planner	Department of National Physical Planning
23	Dr. H.A. Sumanasena	Director	Department of Export Agriculture
24	Mr. R.A.S. Ranawaka	Senior Engineering	Coast Conservation and Coastal Resources Management Department
25	Mr. Piripaharan	Senior Environment Officer	Central Environmental Authority
26	Prof. Buddhi Marambe	Professor, Faculty of Agriculture	University of Peradeniya
27	Dr. B.V.R. Punyawardena	Head/ Climatology Division	Department of Agriculture
28	Mr. M.S.P. Jayawardena	Deputy Director	Meteorology Department
29	Mr. S. Shivatharsan	Fisheries Inspector	Department of Fisheries and AR
30	Mr. Laksiri Nanayakkara	Project Specialist	World Food Programme
31	Mr. Wijendran Paramasami	Project Coordinator	World Food Programme

32	Dr. Athula Senaratne	Research Fellow	Institute of Policy Management (IPS)
33	Ms. Kanchana Wikramasinghe	Research Economist	Institute of Policy Management (IPS)
34	Mr. Chathura Rodrigo	Research Economist	Institute of Policy Management (IPS)
35	Mr. Vajira Bandara	Project Officer	Institute of Policy Management (IPS)
36	Dr. R.D.S. Jayathunga	Director (Climate Change)	Ministry of Mahaweli Development and Environment
37	Mr. Ajith Silva	Director (Policy and Planning)	Ministry of Mahaweli Development and Environment
38	Ms. H.N.K. Dulani	Assistant Director, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
39	Mr. Ranjith Rajapaksha	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
40	Ms. K.K.S. Priyanthi	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
41	Ms. Iresha Rajapaksha	Environment Management Officer Climate Change Secretariat,	Ministry of Mahaweli Development and Environment
42	Ms. Ambika Tennakoon	Environment Management Officer, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
43	Mr. Upul Premalal	Research Assistant, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
44	Ms. Hasula Wikramasinghe	Programme Assistant, Climate Change Secretariat	Ministry of Mahaweli Development and Environment
45	Ms. Methmali Rajaguru	Programme Assistant	Ministry of Mahaweli Development and Environment

Climate Change Secretariat
Ministry of Mahaweli Development and Environment
No: 980/4 A, Wickramasinghe Place,
Ethul Kotte, Sri Lanka.
Tel: +94 (0) 11 2883481 / +94 (0) 11 2883368
Fax: +94 (0) 11 2076782
E-mail: climatesec@gmail.com
Web: www.climatechange.lk

Annex V

පරිසර අමාත්‍යාංශය
சுற்றாடல் அமைச்சு
Ministry of Environment

දුරකථන / தொலைபேசி / Telephone: 0112034132-4, 0112034138
ෆැක්ස් / பெக்ஸ் / Fax: 0112879954
විද්‍යුත් තැපෑල / மின் அஞ்சல் / E-mail: minister@env.gov.lk

"සොබාදම් පියස", අංක 416/සී/1, රොබට් ගුණවර්ධන මාවත, බත්තරමුල්ල, ශ්‍රී ලංකා.
"சொபாதம் பியச", இல. 416/சீ/1, ரொபர்ட் குணவர்தன மாவத்தை, பத்தரமுல்ல, இலங்கை.
" Sobadam Piyasa", No. 416/C/1, Robert Gunawardhana Mawatha, Battaramulla, Sri Lanka.

මගේ අංකය எனது இல. My No.	04/04/10/56	ඔබේ අංකය உமது இல. Your No.		දිනය திகதி Date	23rd Sept. 2021

The Executive Secretary
United Nations Framework Convention on Climate Change

SUBMISSION OF AMENDMENT TO THE UPDATED NATIONALLY DETERMINED CONTRIBUTION OF SRI LANKA

Sri Lanka submitted its updated Nationally Determined Contributions (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) on the 30th July 2021.

Considering the efforts by the Power sector to achieve carbon neutrality in electricity generation by 2050 and to achieve 70% renewable energy in electricity generation by 2030 and the contribution of the other mitigation sectors to reduce greenhouse gas emissions, the target of achieving carbon neutrality has been advanced to 2050, instead of 2060.

Therefore, the amendment to the Updated Nationally Determined Contributions of Sri Lanka is hereby notified as "Sri Lanka expects to achieve its carbon neutrality by 2050''in the 'Key Highlights of Sri Lanka's Nationally Determined Contributions and Vision for a Low Carbon Future' (pg. iv).

The Sri Lankan government further, affirms its commitment to the UNFCCC and the Paris Agreement on Climate Change.

Dr. Anil Jasinghe
Secretary, Ministry of Environment, Sri Lanka
National Focal Point to the United Nations Framework Convention on Climate Change

SRI LANKA

UPDATED NATIONALLY DETERMINED CONTRIBUTIONS

September – 2021

MINISTRY OF ENVIRONMENT

Table of Contents

List of Figures

List of Tables

Executive Summary

Sri Lanka, as Party to the Paris Agreement, presents its updated Nationally Determined Contributions (NDCs) to the United Nations Framework Convention on Climate Change (UNFCCC) through this document reflecting progressive and the highest possible ambition for climate action.

Sri Lanka is ranked among the countries that are most vulnerable to climate change-induced hazards. Being a tropical island in the Indian Ocean, Sri Lanka has consistently been placed among the top ten countries at risk of extreme weather events by the Global Climate Risk Index.[1] Sectors that contribute significantly to Sri Lanka's economy tourism, fisheries, tea plantations and agriculture are climate-sensitive and impacted by the disruption of monsoons and altered rainfall. In 2016 and 2017, Sri Lanka's economy contracted due to prolonged drought and widespread flooding. Climate change projections predict long-term changes to the monsoon pattern and shifting of ecological regions.

Sri Lanka is a low carbon emitting country with per capita emissions of around 1.02 tonnes/per person[2], and its development pathway has remained low-carbon-intensive. A recent analysis of the interplay between per capita emissions and human development, picks out Sri Lanka as a rare example of a country that has achieved both high human development and managed to keep CO_2 emissions well below the long-term average needed to contain global warming targets of the Paris Agreement[3].

Sri Lanka is still on an upward development trajectory with ambitions of achieving upper-middle-income status in five years and further improving its human development outcomes. Demand for energy, clean water, efficient transportation, better connectivity, and waste management is growing among both rural and urban populations. The government has pledged accelerated rural development and provision of better infrastructure in burgeoning cities, suburbs, and villages. The government commits to development that is culturally sensitive and environmentally sustainable in its overarching policy framework '*Vistas of Prosperity and Splendor'* envisioned by His Excellency Gotabaya Rajapaksa, the President of Democratic Socialist Republic of Sri Lanka.

Sri Lanka has some unique advantages and experiences in its journey. Historically, sustainable principles were embedded in land use, agriculture, water management, and other economic practices. Religious and cultural practices value simplicity, non-materialism and sustainable consumption. Public investments in health and education services have created a legacy of high literacy and longevity resulting in high human development and early achievement of the Millennium Development Goals (MDGs). In recent years, however, development investments have been eroded by floods, drought and landslides and the economy has been immensely burdened by disaster relief. Reflecting this trend, the National Climate Change Policy of Sri Lanka leans heavily on adaptation, with a vision to minimize climate change impacts on its fragile ecosystems and economy.

Despite the low carbon footprint and high vulnerability to climate change, Sri Lanka commits to reducing its GHG emissions. In these NDCs, the country presents an enhanced ambition which include 4% unconditional and 10.5% conditional emission reduction commitments with respective to Business-As-Usual (BAU) scenario. This document is organized sector-wise detailing Sri Lanka's climate change mitigation commitments and adaptation needs, loss and damage, and means of implementation. It sets out the process and institutional architecture for implementation; and discusses the critical need for external support with financial, technology transfer and capacity development provision to fully realize these commitments. With such timely support, Sri Lanka is positioned to demonstrate a development pathway that successfully de-couples human development and economic prosperity from carbon-intensive consumption and production.

[1] www.germanwatch.org
[2] Calculated on the basis of total emissions in the 2010 GHG Inventory of the Third National Communication excluding LULUCF.
[3]Pascale, A., Chakravarty, S., Lant, P., Smart, S. and Greig, C., 2020. The rise of (sub) nations? Sub-national human development, climate targets, and carbon dioxide emissions in 163 countries. Energy Research & Social Science, 68, p.101546

Key Highlights of Sri Lanka's Nationally Determined Contributions and Vision for a Low Carbon Future

Sri Lanka is highly vulnerable to the adverse impacts of climate change. The country focuses on building the resilience of **Agriculture, Fisheries, Livestock, Health, Water, Biodiversity, Coastal and Marine, Tourism, Urban Planning and Human Settlement** sectors

Sri Lanka's per capita greenhouse gas emission in 2010 was **1.02** tons and its global cumulative contribution in 2019 was **0.03%.**

Despite this low carbon footprint and highly vulnerable status, Sri Lanka commits to increase **32%** forest cover by 2030 and reduce greenhouse gas emissions by **14.5%** for the period of 2021-2030 from **Power (electricity generation), Transport, Industry, Waste, Forestry, and Agriculture**

In order to realize this ambitious target, Sri Lanka further commits;

- To achieve **70%** renewable energy **in electricity generation** by 2030
- To achieve **Carbon Neutrality** by 2050 in electricity generation
- **No** capacity addition of **Coal** power plants

Sri Lanka has already launched following major initiatives;

- Adopting 'Colombo Declaration on Sustainable Nitrogen Management' with an ambition to halve nitrogen waste by 2030
- Banning agro-chemicals and chemical fertilizer
- Promoting organic fertilizer and farming
- Banning single-use plastics
- Promoting E-mobility
- Promoting circular economy

Sri Lanka expects to achieve its **Carbon Neutrality** by 2050

Chapter 1. Introduction

Sri Lanka submitted its initial NDCs in September 2016 as a country that ratified the Paris Agreement. In 2020, the Climate Change Secretariat began a process of updating the NDCs to be submitted to the United Nations Framework Convention on Climate Change prior to the 26th Conference of Parties.

The updated NDCs represent 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. These NDCs present new evidence on Sri Lanka's climate vulnerability, based on a recent analysis. Further, the NDCs present opportunities that have emerged through development partner-supported initiatives on low-carbon development pathways for key sectors such as power, transport, industry, waste, agriculture and forestry. They spell out urgent financial, technology transfer, and capacity building requirements, in line with Article 2 of the Paris Agreement, to fully adopt a resilient and low-carbon development pathway to upper-middle-income status.

These NDCs are fully integrated into the country's sustainable development vision and are underpinned by policy targets in the national policy framework '*Vistas of Prosperity and Splendor'* envisioned by His Excellency Gotabaya Rajapaksa, the President of Democratic Socialist Republic of Sri Lanka. The National Climate Change Policy of Sri Lanka (2012) describes the national commitment as *"Adaptation to and mitigation of climate change impacts within the framework of sustainable development"*. The recently developed National Policy and Strategy for Sustainable Development (Draft) has adopted a policy goal of achieving '*national commitments on climate change, while ensuring adaptation to and mitigation of climate change impacts'*.

To support NDC implementation and monitoring in 2016, Sri Lanka prepared a Readiness Plan 2016-2019, which detailed out actions to facilitate pre-requirements for achieving the NDCs. This Plan was reviewed at Annual Steering Committee Meetings that convened the key sectors contributing to mitigation, adaptation and loss and damages. To achieve the NDCs, relevant sector agencies at the national and sub-national levels are expected to embed NDCs into the regular development planning framework. This will ensure that mitigation and adaptation priorities are reflected in and integrated into workplans, annual budgets and donor proposals of these agencies.

Sri Lanka's NDCs are expected to be supported by external assistance, public funds, and private sector investment. Sri Lanka will prioritize adaptation needs and resilience-building activities, focusing on key sectors -agriculture, livestock, fisheries, water, health, biodiversity, coastal and marine, urban planning and human settlements, and tourism. For Sri Lanka, focusing on adaptation is critical to ensure that development investments are not eroded by constant exposure to climate extremes and that the country remains on track to achieve its ambitions of economic growth and human prosperity. Investments in mitigation will be prioritized based on emission intensities and the economic, social or environmental co-benefits derived from these actions.

As a global citizen, Sri Lanka recognizes its responsibility to uphold the Paris Agreement's objective of containing global warming. It will strive to steer development, especially post-Covid economic recovery and livelihood needs, along a low-emission trajectory that supports both mitigation of and adaptation to climate change, with a strong focus on reaching high income and human development in the next decade. Therefore, Sri Lanka reaches out to the global community for technical, financial and additional capacity needs outlined in Chapter 9 for effective NDC implementation and to keep the country on a low carbon trajectory as it strives for greater economic and social well-being of its people.

1.1 Country Context

An island nation of 65,610 square-kilometers and a population of 21.8[4] million, Sri Lanka is fairly densely populated, especially in the urbanized and industrialized south-western coastline of the country. Situated in the humid tropics at 7° North of the Equator, Sri Lanka receives an average of 1860 mm rainfall annually, amounting to approximately 122 billion cubic meters of water. However, rainfall varies regionally between 5500mm in the central hills to around 950mm in the coastal plains of the northwestern and southeastern ends. Mean annual temperature varies between 24°C-31°C in the plains and 18°C-27°C in the mountainous region. Annual rainfall is spread over four seasons- two monsoons and two inter-monsoons.

For a country of its size, Sri Lanka has a complex climatology giving rise to over 45 agro-climatic zones. However, for general purposes the country is divided into three main climatic zones defined by rainfall - the Wet Zone, in the rain-rich southwestern quarter, the Intermediate Zone separating it from an extensive Dry Zone in the north, north-central and eastern plains. The plains surrounding the coast give way to a central mountainous region that rise to over 2,000 m above sea level. The country claims a marine economic zone nearly twenty times its land area- however this resource is least exploited economically.

A diverse topography and varied tropical climate have given rise to extremely high levels of faunal and floral diversity, and high rates of endemicity. Around 30% of the country’s land is protected by law as sanctuaries, reserves and national parks. This biodiversity supports a considerable economic benefit through tourism, fisheries, traditional medicine, and provides unaccounted for ecosystem services such as water, aesthetic beauty, climate amelioration and soil conditioning. Threats to biodiversity from the changing climate have not been studied adequately but early research illustrate the significant impact on endemic taxa like fishes, amphibians and reptiles, and drastic changes in coastal habitats such as corals, sea grasses and lagoons.

Sri Lanka is classified as a lower-middle-income country and its economy is largely dependent on services such as shipping, tourism, aviation etc. Services accounted for 58.2% of Sri Lanka's economy in 2019 up from 54.6% in 2010, industry 27.4% up from 26.4% a decade earlier and agriculture declined to 7.4%. Despite a competitive export orientation, especially tea and spices, agriculture has declined in economic importance, despite still employing 30% of the workforce. There are around 2 million farmers and a majority of them are small-scale, cultivating less than 1ha. Successive governments have invested in agriculture and expanding irrigation; however, climate change is already adversely impacting on food security and livelihoods and export revenues. Due to prolonged drought in the tea-growing districts, tea yields in 2020 dropped to a 30-year low. Over one million farmers were impacted by flood events in 2016 and 2017. Sri Lanka is currently ranked 66/113 on the Global Food Security Index (2019), while the FAO estimates that 4.1 million out of the 21 million population (over 25% of the population) do not have nutritious food to maintain healthy lives. Child malnutrition, denoted by high rates of stunting and wasting among children, presents a development challenge. These will be exacerbated by predicted climate change.

Sri Lanka has an impressive track record of tackling poverty. The overall poverty rate is 4.1%[5] showing commendable progress from 20 years ago (28.8% in 2000). However, there is wide disparity in poverty

[4] Economic and Social Statistics of Sri Lanka 2020, Central Bank of Sri Lanka
[5] Department of Census and Statistics, Household Income and Expenditure Survey 2016

incidence; districts characterized by low population density, low service penetration and largely agriculture-dependent display much higher rates of poverty (Moneragala, Mullaitivu, Nuwara Eliya and Batticaloa). These districts display higher vulnerability to climate change due to enhanced sensitivity to climatic parameters and lower capacity to withstand climate hazards. In Sri Lanka, a considerable percentage live just above the poverty line. The World Bank assessed in 2015 that one in four people live on less than $2.50 per day. This population is negatively affected by economic or climatic shocks, and their ability to recover and resume livelihoods is compromised by lack of safety nets and savings.

Sri Lanka's vulnerability to climate change is exacerbated further by the fact that the majority of its population live in rural areas and continue to engage in small- scale farming, fisheries or are employed in the agricultural value chain. Sri Lanka's low urbanization has contributed in no small measure to its overall low-emission growth trajectory. However, this rural lifestyle is increasingly threatened by extreme weather events and anomalies related to the regular monsoon pattern around which the rural economy is organized.

Sri Lanka's unemployment is low. However, both labour force participation (52.3%) and the contribution of women to the formal labour force (34%) are low for a middle-income country. Unemployment among more educated youth is high (11% in 2019) displaying a widening gap between education attainment and employable skills. Women have higher educational attainment and are more likely to complete 13 years of formal schooling. The investments in free schooling and human capital development through vocational and tertiary education have created a literate and young workforce that can benefit from technologically advanced, green jobs. A high level of Information Communication Technology (ICT) penetration and mobile phone usage in Sri Lanka also provides impetus to this opportunity to provide more gainful employment and environmentally friendly livelihood opportunities, especially for youth living in remote rural areas.

The Covid-19 pandemic has significantly impacted Sri Lanka's economy. Lockdowns, travel restrictions and border closing to manage multiple waves of the disease with increasing ferocity and mortality, have depressed the economy and forced the government to offer lifelines to keep vital sectors afloat. This includes tourism, manufacturing, transportation and remittances from expatriate workers. Products that had good global demand during the pandemic- like tea and coconut- were impacted by drought and low production. 2020 recorded negative economic growth and there is a strong impetus to spur on growth and incentivize domestic production. The government committed to a green development framework around the key environmental issues that impact Sri Lanka. Such policies, if backed with fiscal incentives and technical assistance, can direct recovery efforts towards greater sustainability. There are some concrete areas of investment Sri Lanka could potentially consider during post-Covid recovery situation, which have been discussed during the NDC revision process. These are;

- Ensuring domestic food production systems -agriculture and fisheries- are climate-sensitive and environmentally sustainable;
- Incentives for women to engage in agriculture productivity and food security efforts;
- Promoting efficient water management and irrigation systems;
- Enhancing the capacity of the health sector including digitization of services and sustainable health/hospital waste management;
- Enabling policies and incentives for renewable energy, energy efficiency, waste management, green industry and transportation initiatives etc. to reduce GHG emissions;
- Diversify the economy to generate multiple co-benefits to address the severe negative impacts of Covid-19 on livelihood especially to the tourism sector.

Chapter 2: National Vision and Responses to Climate Change

In response to challenges posed by climate change, Sri Lanka has taken several steps by introducing national policies, strategies and actions such as the National Climate Change Policy of Sri Lanka (2012), National Climate Change Adaptation Strategy for Sri Lanka in 2010, the National Adaptation Plan (NAP) for climate change impacts in Sri Lanka (2016), Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation and Mitigation (2014), Nationally Appropriate Mitigation Actions (NAMA) for energy, and Climate Change Sector Vulnerability Profiles (2010) in order to address climate change-induced impacts.

Sri Lanka's climate change and national sustainable development-related policies seek to mainstream climate change into key sectors such as power, 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. Importantly, National Energy Policy & Strategies of Sri Lanka (2019) and Long-Term Electricity Generation Expansion Plan 2018-2037, the National Policy on Waste Management (2019), the National Policy on Sustainable Consumption and Production for Sri Lanka (2019), Coastal Zone and Coastal Resource Management Plan 2018, National REDD+ Investment Framework and Action Plan (NRIFAP) 2017, Strategic Action Plan for Adaptation of Irrigation and Water Resources Sector for Climate Change 2018, National Policy on Natural Gas (2019), National Policy on Disaster Management (2013), Sri Lanka Disaster Management Plan 2018-2030, Overarching Agriculture Policy (under revision) have integrated climate change impacts and mitigation measures; and has spelt out strategies for low-emission development. The power sector has recorded some impressive developments in mobilising private investments into renewable energy expansion in recent years. Attractive feed-in tariff rates, solar net-metering and net accounting, attractive financing for solar rooftop expansion, energy efficiency labelling for certain appliances and phasing out incandescent lighting have resulted in a proliferation of renewable energy to the grid and reducing energy demand.

Sri Lanka's conditional NDCs for GHG mitigation will require extensive international support to be realized. In the next ten years, Sri Lanka will seek climate financing and technology transfer support towards exploiting more renewable energy resources, expanding energy storage systems and upgrading its electricity distribution network, efficient and effective waste to energy systems, modernizing public transportation, upgrading its road and railway network etc. Meanwhile, the Government of Sri Lanka has taken multiple measures to address climate vulnerability and the impacts of weather-related hazards on lives and livelihoods. These include investments in developing/fortifying the eroding coastline, expanding irrigation and trans-basin diversions to moderate drought, develop meteorological capacity and early warning capacity for floods/landslides. Resettlement of communities living in landslide and flood-prone areas is on-going. Disaster exposure and by extension climate-related vulnerability is increasingly being factored into the design and implementation of development projects such as roads, reservoirs and new settlements, however often the full range of mitigatory measures is both financially and technologically challenging for a developing country.

Chapter 3: NDC Revision Process

The NDC review process was launched in 2020 through the Climate Change Secretariat of the Ministry of Environment. UNDP's support to the process was obtained through a global project named ***Climate Promise*** that sought to support 100 countries to upgrade their climate change ambitions in 2020 ahead of COP 26. This support was launched in February 2020. Working groups consisting of experts and professionals were established for each sector under mitigation and adaptation, while the loss and damage discussion was co-led by the Disaster Management Centre and the Climate Change Secretariat.

As a first step, desk reviews of the 2016 NDCs were undertaken by national consultants based on available materials including national policy documents, sectoral master plans, National Adaptation Plan for Climate Change (2016-2025), Technology Needs Assessment for Climate Change Adaptation and Mitigation, and the draft Third National Communication (TNC) including the inventory of greenhouse gases prepared for the TNC. The findings were verified through discussions with technical working groups for each sector. For efficiency, the NDCs built upon recent discussions and analysis of climate risks and vulnerability, including those completed for the Third National Communication (draft),and Climate Change Risk in Sri Lanka – Sector Risk Profile (draft), Marginal Abatement Cost Curves analysis for energy, Low-Carbon Development Strategy (draft), National Disaster Management Plan (draft) and National REDD+ Investment Framework and Action Plan.

Due to restrictions on physical meetings imposed to control the spread of Covid-19 through March-May 2020, virtual meetings and discussions were held with all working groups and the core NDC team. The draft NDCs were then presented to wider groups of stakeholders (by sector) from July to September 2020 when restrictions were relaxed enabling physical meetings and discussions.

Separate discussions with lead sectoral agencies/Ministries were held to understand the development priorities, institutional structures, public finance availability and financing and capacity needs for NDCs in each sector. Detailed implementation plans will be prepared for each sector with clearly identified actions/sub-actions, targets and responsible agencies. These will be integrated, as fully as possible, into the regular planning cycles of these sectors ensuring smooth delivery. Finally, an assessment of the cost of achieving NDCs in order to develop a financing strategy has been commissioned. The Financing Strategy will be communicated to the international community as an addendum to the NDCs.

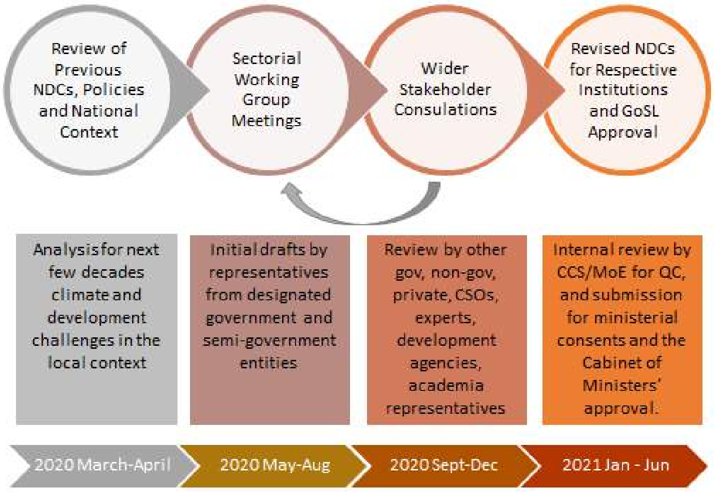


Figure 3. 1: NDC Revision Process

Chapter 4: Mitigation NDCs

4.1 Climate Change Mitigation in Sri Lanka

As described in Chapter 1 and 2, Sri Lanka's economic and human development has been largely 'low-carbon' aided by decades of public investment in education and health, non-reliance on energy-intensive heavy industry for economic growth and continued exploitation of indigenous energy sources such as wind, hydro, solar and biomass. The country is recognized as a rare global example of how human wellbeing and economic prosperity can be decoupled from carbon-intensive development and lifestyles.[6] However, there is room for further GHG reduction while continuing an upward development trajectory. Therefore, these NDCs present an increased ambition for GHG reduction (over the initial NDC in 2016) generated largely through improved target setting in six sectors; electricity (power; electricity generation and end-use), transport, industry, waste, forestry, agriculture (including livestock). Mitigation actions with high GHG abatement potential and closely aligned with sustainable development objectives of the country have been prioritised for implementation over the period 2021 to 2030.

To develop these NDCs, Sri Lanka's policies and strategies on the above six sectors were reviewed along with the National Environment Policy, National Climate Change Policy, National Policy for Sustainable Development (draft) and National Policy for Sustainable Consumption & Production. In general, low-carbon and energy-efficient practices, circular economy concepts and promotion of GHG sinks by improving forest/tree cover are supported through the above policy directions. In the past five years, Sri Lanka has taken several proactive steps, introduced policy instruments and financial incentives to develop a low-carbon pathway.

The power sector, for example, has enabled private investment in renewable energy by supportive policy instruments such as feed-in tariffs, net-metering and net-accounting. Energy efficiency has been incentivised by high energy rates rationalising consumption, Time-of-Use (TOU) billing etc. and supported through financial incentives to replace incandescent lighting with LED in a short timeframe. Waste-to-energy investments and waste composting measures in key municipalities have substantially increased managed waste in urban areas. Regulatory restrictions and environmental considerations have forced large-scale waste producers- such as livestock farms, hotels- to invest on in-site waste treatment and management.

Industry has embraced energy efficiency, circular economy concepts and cleaner production. Some larger industrial production facilities are now going for 'carbon-neutrality' for marketing advantage and sustainability. The sector pledged to adopt 'green or eco' concepts when investing in new industrial parks.

The transport sector has seen a modal shift from public to private which is in keeping with middle-income development aspirations. Significant investments are lined up to upgrade passenger transport systems including the long ailing railway and expressway network, introduce modern conveyance systems in congested urban centres and promote more hybrid and electric vehicles among private users.

[6] https://iopscience.iop.org/article/10.1088/1748-9326/9/1/014011/pdf

4.2 Unconditional and Conditional Policy Responses

Sri Lanka interprets **unconditional** policy responses as those actions that have been identified in national plans and programmes, prioritised for domestic investments (public and private) which can be implemented with domestic capacity. These actions amount to 4.0%[7] of GHG emissions reduction with respective to BAU scenario for the period 2021-2030.

Conditional policy responses require external support including financing, technology transfer, and capacity building. Many conditional NDCs are constrained by their lack of market readiness (economic viability) and immaturity of the technology. Conditional NDCs form the majority of the actions described in the following sectors. These actions are important for long-term course-change in key sectors; –power, transport, industry, waste, forestry, agriculture & livestock- towards low-carbon pathways. Sri Lanka is keen to propel its growth towards upper middle-income status by enabling better rural services, improving liveability and efficiency in urban areas and encouraging the growth of services and manufacturing, especially of value-added agricultural products. In this background, conditional NDCs have been framed around an analysis that presents the country's commitment to maintaining its trajectory of low-emission growth with international financial and technical assistance. These conditional NDC actions account for additional 10.5%[7] of GHG emissions reduction respective to the BAU scenario for the period 2021-2030.

4.3 Implementing and Monitoring Mitigation NDCs

NDCs will be 'projectized' into fundable actions and further developed for private sector investments, public financing through the Government's budget or through international funding agencies by developing proposals for climate financing. This process will involve detailed feasibility of the actions themselves, a thorough analysis of the sustainable development co-benefits and financing options. This process presents the opportunity to conduct detailed gender and social analyses of the actions and propose any mitigatory steps to overcome risks. Gender and sustainable development co-benefit analysis is mandatorily required in Sri Lanka's national planning project format.[8] Environmental and social impact assessments will be carried out as required for the larger projects that involve land conversion or infrastructures.

Around 40 mitigation actions classified under the six sectors mentioned above contribute to Sri Lanka's total GHG emissions reduction target. However, there will be further GHG emissions reduction from unquantified mitigation actions which cannot be quantified due to lack of baseline and emissions reduction potential information at present. These GHG emission mitigation potentials and actual achievements will be accounted and communicated in the future after baseline data and necessary sectorial MRV mechanisms are fully established with necessary internal and external support. Further, there are certain adaptation actions described in Chapter 5 that contribute to GHG emissions reduction. The emissions reduction from climate adaptation actions in sectors such as livestock, tourism, and urban settlements, have not been accounted for in the overall GHG emission calculations presented above. Hence these mitigation benefits will be additional to Sri Lanka's total emissions reduction target.

[7] For the six sectors covered in this revision (power, transport, industry, waste, agriculture & livestock, forestry). Analysis excluding the emissions & emissions reduction activities in certain sub sectors such as some land use categories.
[8] http://www.npd.gov.lk/index.php/en/2017-03-02-07-02-41/project-submission-format.html

4.4 Sectoral Mitigation NDCs

4.4.1 Electricity (Power) Sector

Sri Lanka has achieved nearly 100% electrification for all potential users of the country -barring a few isolated communities. The total installed power generation capacity in 2019 was 4,217 MW, of which around 50% consists of renewable energy including large and small hydro, wind, solar, and biomass. The rest is generated through coal and oil-based thermal power. Sri Lanka's annual electricity demand was approximately 14,611 GWh in 2019. Around 35% of this demand was met by renewable energy resources in 2019. The demand for electricity is expected to grow by 5% annually and future electricity generation expansion programs are expected to meet this demand growth.

Sri Lanka has taken several recent initiatives to implement sustainable energy programmes. Key principles in the Energy Policy (2019) guides the country to further develop indigenous renewable energy sources to the optimum level, diversify the generation mix and minimise dependence on imported fossil fuels. It is stated that renewable energy sources should be developed considering resource potential, economics, maturity of technology and quality of supply. These initiatives are expected to bring renewable energy based power generation to the fore-front, with a target of realizing 70% electricity generation using renewable energy sources by 2030.

Future Outlook and GHG Emissions Reduction Potential in Electricity (Power) Sector: National Energy Policy (2019) primarily focuses on ensuring energy security, equity, and sustainability of the energy supply. As it is essential to maintain a regular power supply with a practical and a balanced energy mix, the firm capacity should be maintained with Liquified Natural Gas (LNG) or indigenous natural gas, high-efficient coal power, large storage hydro, furnace oil refined from national refinery and non-conventional renewable energy sources[9] which can provide the firm/ base power requirement. Aligning with the *Vistas of Prosperity and Splendour*, significant growth in increasing power generation through wind, solar, hydro and biomass is expected. In addition, Demand Side Management (DSM) activities, and transmission and distribution loss reduction activities will support emissions reduction. Furthermore, converting existing fuel oil-based combined cycle power plants to natural gas and introducing new natural gas-based power plants will support emissions reduction efforts, contributing to NDCs.

Furthermore, no new coal power plant addition is expected for the future, and converting existing fuel oil based combined cycle power plants to natural gas and introducing new natural gas based power plants will support emission reduction efforts, contributing to NDCs. The long-term target of the power sector is to achieve carbon neutrality in 2050, based on which the National Energy Policy & Strategies has been framed.

Key interventions envisaged for GHG emissions reduction up to the year 2030:

- Development of hydro-power base to its maximum potential through new large and small hydro-power plants amounting to around 300 MW.
- Develop approximately 800MW of wind power generation in Northern and North-Western coastal areas of the island.
- Develop approximately 2,000 MW of solar power capacity using different modalities such as solar rooftops, small scale, and large solar PV power plants.

[9]Small hydro, solar PV, wind, biomass, biogas and other agro-waste power plants.

- Power generation through biomass and municipal solid waste will also be added with an expectation of a reasonable contribution to power generation.
- Facilitate the implementation of pilot-scale projects using new renewable energy sources that have not yet reached commercial maturity and other grid supporting infrastructures including behind the meter (BtM) and grid-scale energy storage solutions to assist more renewable energy integration.
- Pursue Pumped Storage Hydro Power Plant development to accommodate higher level of intermittent and weather-dependent renewable energy to the power generation system.
- Continue the loss reduction initiatives of the transmission and distribution network.
- Convert existing fuel oil-based combined cycle power plants to use natural gas and to develop new natural gas plants as an alternative to planned coal power plants (depending on infrastructure availability for natural gas).
- Implement Demand Side Management activities through a five-year national Energy Efficiency Improvement and Conservation (EEI&C) programme.
- Introduce policy supportive measures such as tax benefits, low-interest financing, etc. to expedite the implementation of renewable energy development and energy efficiency improvement programmes.
- Engage in viable carbon trading mechanisms to promote the shift towards clean energy sources.

In order to achieve NDCs, activities have been identified (Table 4.4.1); some are quantifiable while others, though not quantifiable, are supportive and essential for effective implementation[10].

Table 4.4.1: NDCs in Electricity (Power) Sector

NDC #	NDCs and NDC Actions	Timeline
NDC 1	**Enhance renewable energy (RE) contribution to the national electricity generation mix by increasing solar PV, wind, hydro and sustainable biomass-based electricity generation** **(Target: Develop an additional capacity of 3,867 MW renewable energy over the RE capacity considered in Business-As-Usual scenario, out of which approximately 950 MW are on an unconditional basis and 2,917 MW on a conditional basis)[11]**	**2021-2030**
	1.1 Establish wind, solar (rooftop, small-scale and large solar PV), biomass[12], large and small hydro power plants	2021-2030
	1.2 Develop required transmission network infrastructure to enable the integration of renewable energy	2021-2030
NDC 2	**Implement Demand Side Management (DSM) measures by promoting energy-efficient equipment, technologies, and system improvements in a national Energy Efficiency Improvement and Conservation (EEI&C) programme**	**2021-2030**
	2.1 Realize energy saving of 2,603 GWh by phasing out incandescent bulbs as a conditional measure	2021-2025
	2.2 Realize energy saving of 5,189 GWh by introducing efficient lighting, fans, refrigerators, and chillers as a conditional measure	2021-2030
	2.3 Implement Energy Efficiency Building Code on a mandatory basis	2021-2022

[10] When determining the NDC activities, the unconditional targets were declared based on the financial and technical capability already available in the country. Targets that require external financial and technical support to supplement the domestic capacity are declared as conditional targets. External technical and financial supports are vital factors for the successful accomplishment of these goals, which renders them as conditional

[11]It should be noted that, conditional target in above NDC Action 1 is based on interim results of ongoing national planning exercises, which shall be validated subjected to grid limitations such as operational flexibility, system stability, etc. In achieving this conditional target, grid reinforcement measures and enabling technologies such as energy storage shall be required

[12]Power generation through sustainable biomass resources

	2.4 Promote High-Efficiency Motors (HEM), Variable Frequency Drives (VFD), tri-generation, and other energy efficiency measures in the industrial sector	2021-2030
NDC 3	**Conversion of existing fuel oil-based combined cycle power plants to Natural Gas (NG) and establishment of new NG plants as conditional measures (once the necessary infrastructure is available)**	**2021-2027**
	3.1 Conversion of existing 600 MW of fuel oil-based combined cycle power plants to NG	2021-2026
	3.2 Establishment of new combined cycle power plants in place of anticipated coal power capacity additions in the BAU and gas turbines with approximately 700 MW of capacities to be operated from NG	2021-2027
NDC 4	**Transmission and distribution network efficiency improvements (Loss reduction of 0.5% compared with BAU by 2030) as an unconditional measure (Target: Approximately 1,848 GWh energy savings)**	**2021-2030**
	4.1 Carry out developments in the transmission network, re-conducting of existing transmission lines, and reactive power compensation activities	2021-2030
	4.2 Carry out the conversion from bare conductors to bundled conductors, improved construction & maintenance practices in the distribution network	2021-2030
NDC 5	**Conduct R&D activities to implement pilot-scale projects for Non-Conventional Renewable Energy (NCRE) sources that have not yet reached commercial maturity and develop other grid supporting infrastructures as conditional measures**	**2021-2030**
	5.1 Conduct R&D activities to implement pilot-scale projects for new renewable energy sources which have not yet reached commercial-scale maturity	2021-2030
	5.2 Develop Pumped Storage Hydro Power Plants and pilot scale storage systems such as Behind the Meter (BtM) and Grid-Scale Energy Storage Solutions to support the integration of renewable energy to the system by improving system flexibility	2021-2030
	5.3 Introduce ICT interventions such as Smart Grid technologies to support the integration of intermittent renewable energy into the system	2021-2030

It is expected that the implementation of updated NDCs will result in GHG emissions reduction against BAU scenario by **25%** in the electricity sector **(5% unconditionally and 20% conditionally)** equivalent to an estimated mitigation level of 9,819,000 MT unconditionally and 39,274,000 MT conditionally (total of 49,093,000 MT) of carbon dioxide equivalent during the period of 2021-2030[13] (Figure 4.4.1).

[13] The forecasted emissions of the power sector for the period 2021-2030 is 196,373,000 MT as per the BAU scenario of the Long-Term Generation Expansion Plan 2013-2032 of Ceylon Electricity Board published in October 2013 which was the basis of the first NDC commitment.

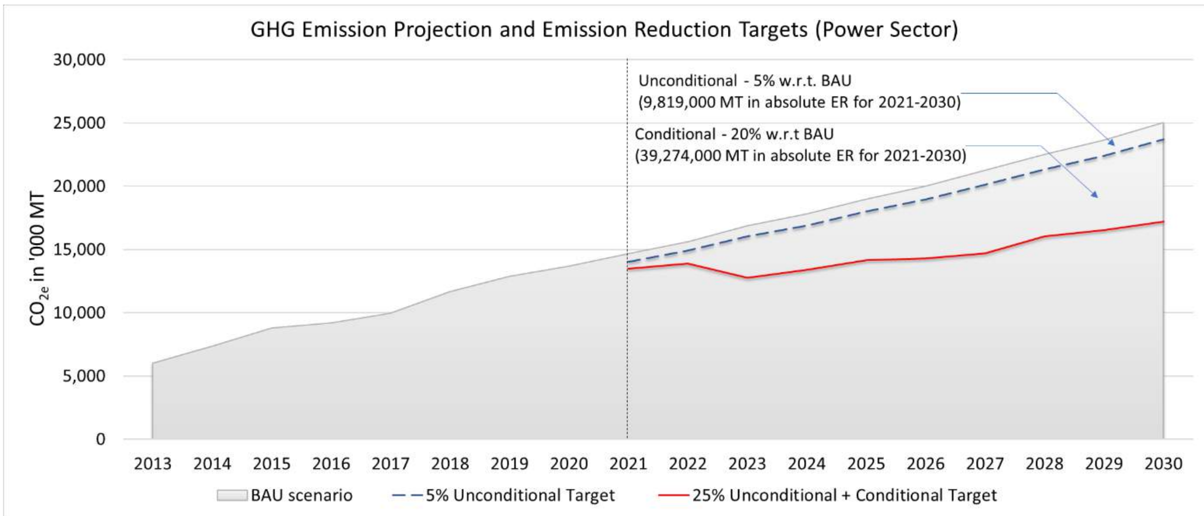


Figure 4.4.1: Emission reduction projections in Electricity (Power) Sector

4.4.2 Transportation Sector

Road transportation is dominant over the railway, air, and sea modalities in Sri Lanka. The present active vehicle fleet of Sri Lanka is around 6.7 million[14], of which 54% are motorcycles, 16% are three-wheelers (motor tricycles), 11% motor cars, and 1% buses. Despite investments and attempts to improve public transportation options, the quality and availability of public transportation are yet below expectation. This and rising per capita income have resulted in a gradual decrease in passengers using public transportation and an increase in private vehicles. In turn, there is increased traffic congestion, a reduction in fuel economy, and higher emissions. All fuel for transport is imported. Although Sri Lanka adopts Euro 4 emission standards and continues with the vehicle emission testing programme, the considerable share of inefficient vehicles in operation leads to higher GHG emissions.

The increase in private vehicle use in urban areas has increased traffic congestion, road accidents and air pollution, and in turn impacts the economy, environment, and society. High dependence on road transport, as against railways or water-based transport modes, tend to increase total energy consumption and air pollution. Though Sri Lanka Railway (SLR) played a dominant role in the past, its share of passenger and freight transportation has shrunk over time. SLR has identified the potential to improve its services as a low-cost mass transportation mode for passengers and goods, and thereby reduce urban and suburban traffic congestion to a great extent. On the other hand, non-motorized transport share is very low in urban areas and is reducing in rural areas. Three-wheelers, school, and office vans are providing substantial services to communities that do not have direct access to buses or trains. Recent infrastructure developments in the sector such as expressways, park & ride facilities, multimodal transport hubs, etc. are expected to reduce the emission footprint while positively contributing to the environment and economy.

Future Outlook and GHG Emissions Reduction Potential in Transport Sector: Under the business-as-usual scenario, the share of public transportation will decline further. However, the updated NDCs are expected to re-invigorate public transportation including railways, buses, and improve intermodal connectivity between rail, road, and water-based transportation. Investments in safe, reliable, accessible, and comfortable public transportation can encourage the shift from private to public. An increase in public transport will reduce traffic delays and congestion. Improvement of energy efficiency/fuel economy in the transport sector becomes a national priority to save foreign exchange contributing to the economy, local and global air pollution, apart from its contribution to GHG emissions reduction as stipulated through the NDCs.

Updated Transport Sector NDCs: The sector has analyzed the abatement costs of different transport sector mitigation options under the Initiative for Climate Action Transparency (ICAT) support. Even though this assessment indicates that there are several emission reduction activities that can be implemented compared to the BAU scenario, the country needs significant financial support to accomplish the identified actions. A comprehensive Measuring Reporting and Verification (MRV) system for the transport sector is being implemented under the same programme. An initial feasibility assessment for the 'Nationally Appropriate Mitigation Actions (NAMA) on Bus Rapid Transport (BRT)' concept was completed in 2015/2016 and expects external support to complete as a comprehensive feasibility and implementation of the same. Strengthening NDCs communicated in 2016 with this evidence/analysis, the following actions (table 4.4.2) are proposed to support transport sector emissions reduction. The development of an environmentally sustainable transport (EST) system, based

[14] https://www.ntc.gov.lk/corporate/pdf/NTCEnglishReport2017.pdf

on the concept of "Reduce-Shift-Improve" supports reducing (or avoiding) the need to travel, shifting to more environmentally friendly modes, and improving the energy efficiency of transportation and vehicle technology (focused on system efficiency, trip efficiency, and vehicle efficiency).

Table 4.4.2: NDCs in Transport Sector

NDC #	NDCs and Actions	Timeline
NDC 1	**Transport sector system improvement**	**2021-2030**
	1.1 Avoid the need to travel	2021-2030
	1.2 Reduce commuting distances and travel time	2021-2030
	1.3 Improve traffic and traffic light management	2021- 2030
	1.4 Improve parking management	2021- 2030
	1.5 Introduce intelligent transport management systems	2021-2030
	1.6 Improve road architecture (road designs, road signs, signaling, signage, etc.)	2021-2030
NDC 2	**Promote public passenger transport**	**2021-2030**
	2.1 Improve public road transport for reliability, affordability, accessibility, availability, comfort and safety	2021-2030
	2.2 Improve railway transport for reliability, affordability, accessibility, availability, comfort and safety	2021-2030
	2.3 Integrate transport modes	2021-2030
	2.4 Improve last mile connectivity	2021-2030
NDC 3	**Shift freight to efficient modes**	**2021-2030**
	3.1 Switch back to rail from road transport	2021-2030
	3.2 Promote transporting petroleum products by pipeline	2021-2030
	3.3 Introduce rail-based transport system with inland container depots	2021-2030
NDC 4	**Rapid transport for passenger transport**	**2021-2030**
	4.1 Introduce Light Rail Transport in Colombo city	2021-2030
NDC 5	**Promote non-motorized transport modes**	**2021- 2030**
	5.1 Promote the use of bicycles	2021-2030
	5.2 Improve the facilities for pedestrian walkways	2021-2030
NDC 6	**Introduce taxes and other instruments to promote public transport**	**2021- 2030**
	6.1 Change the existing vehicle emission charging system from the present vehicle based to vehicle type, fuel used and emission-based system plus the total km travel	2021-2030
	6.2 Restrict the entry of individual modes of transport to sensitive areas and congested areas of major cities during peak hours through a levy	2021-2030
	6.3 Develop park and ride infrastructure developments combined with Corden based pricing mechanism	2021-2030
NDC 7	**Introduce inland water transport modes**	**2021-2030**
	7.1 Introduce **c**anal-based water transport using diesel or grid electricity-powered boat service for selected canal routes	2021-2030
NDC 8	**Modernizing and upgrading of suburban railway**	**2021-2030**
	8.1 Electrification of railway lines	2021-2030
	8.2 Develop new railway lines and expansion of existing railway network	2021-2030
NDC 9	**Promote electric mobility and hybrid vehicles**	**2021-2030**
	9.1 Increase tax concessions for electric & hybrid vehicles	2021-2030
	9.2 Facilitate supportive infrastructure developments such as charging stations, battery swapping & replacements	2021-2030
	9.3 Tax & Duty concessions for batteries used for electric and hybrid vehicles after introducing a specific HS code	2021-2030
NDC 10	**Improve vehicle fleet efficiency**	**2021-2030**
	10.1 Improve efficiencies of the existing vehicle fleet	2021-2030
	10.2 Promote the import of fuel-efficient vehicles	2021-2030
	10.3 Introduce programmes to change driver behaviours	2021-2030

NDC 11	**Road infrastructure development**	**2021-2030**
	11.1 Development of provincial and rural road infrastructure for improved mobility	2021-2030
	11.2 Expansion of expressway network	2021-2030
NDC 12	**Reduce GHG emissions from the marine sector**	**2021-2030**
	12.1 Ratify Annex VI of MARPOL convention to enforce provisions in Sri Lanka	2021-2030
	12.2 Study the impact of shipping on GHG emissions (coastal traffic and ports) depending on evidence-based information and introduce measures to address the issues	2021-2030
	12.3 Promote sea transportation	2021- 2030
	12.4 Introduce energy efficiency measures and fuel quality improvement programmes to coastal shipping and fishing boats and vessels	2021- 2030
NDC 13	**Generic enabling activities**	**2021-2030**
	13.1 Introduce new national policy or make amendments to relevant existing policies to promote environmentally sustainable transport modes including electric mobility and hybrid vehicles	2021-2030
	13.2 Introduce fuel-based carbon tax	2021-2030
	13.3 Include climate change measures in maritime policy making	2021-2030

It is expected that the implementation of updated NDCs will result in GHG emissions reduction against 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 MT unconditionally and 4,011,000 MT conditionally (total of 5,348,000 MT) of carbon dioxide equivalent during the period of 2021-2030 (Figure 4.4.2).

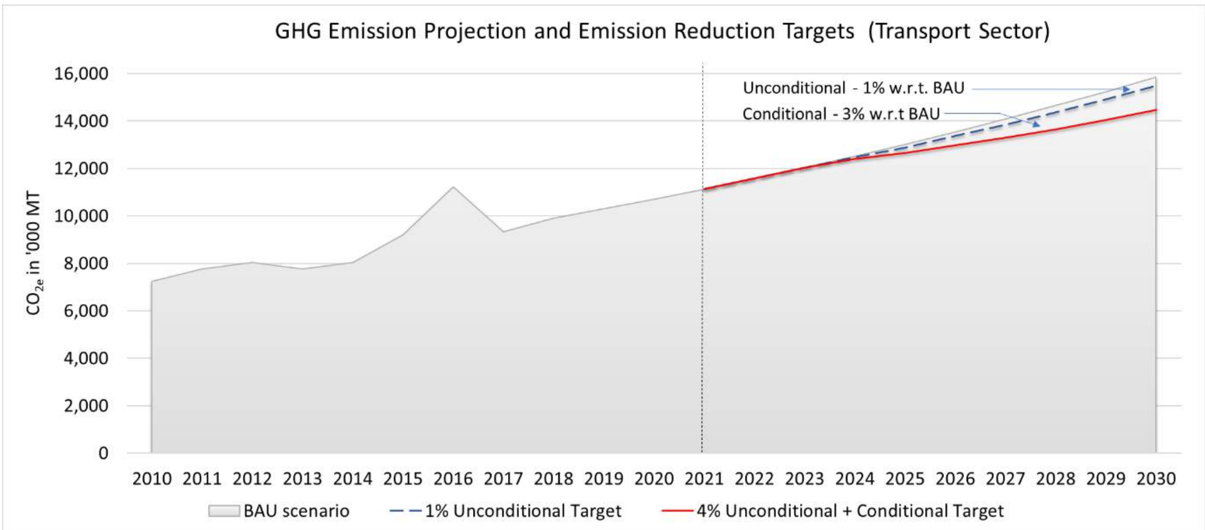


Figure 4.4.2: Emission reduction projections (Transport Sector)

4.4.3 Industry Sector

The industrial survey conducted in 2016 by the Department of Census and Statistics reported 21,295 industrial establishments[15] in Sri Lanka with manufacturing as the largest segment. Industrial production, according to Central Bank Annual Report 2018, is the second-largest contributor to GDP (15.5%) after the service sector (26.1%) and employs 30% of the country's workforce. Textile, apparel, and tea manufacturing are the most significant export-oriented sub-sectors.

As per the Energy Balance 2018 of Sri Lanka Sustainable Energy Authority, the energy required for the industry sector came from three main sources: biomass (33%), petroleum oil (34%) and electricity (33%). Biomass is used in tea and rubber factories, bakeries, tile and brick industries and other small-scale industries. Fossil fuel is used for operating boilers, ovens and furnaces in other industries. The key industries contributing to GHG emissions are cement manufacture, lime production for the construction industry, and industries using limestone and soda ash. However, compared to emissions from industrial energy consumption, industrial processes generate a relatively low level of GHG emissions.

Future Outlook and GHG Emissions Reduction Potential in Industry Sector: The Government of Sri Lanka is focusing on creating a globally competitive, high value-added, innovative, technology, and knowledge-based industry, with a minimal adverse impact on the environment, which could boost the investor confidence and ensure higher export revenues and achieving sustainable development. To reflect this new direction, the Ministry of Industries is now in the process of formulating a National Policy for Industrial Development (NaPID) and a five-year Strategic Implementation Plan to operationalize the NaPID.

Alongside this, the Ministry of Industries is exploring the possibility of implementing industry sector NDCs through the design and implementation of policy, as well as regulatory, technical & financial mechanisms and tools to accelerate the deployment of renewable energy, energy & resource- efficient technologies and best practices. These NDCs (Table 4.4.3) will enhance mitigation ambitions while embracing and incorporating resource efficiency, circular economy and other internationally acclaimed concepts. It is noted that these NDCs are directly or indirectly addressing energy-consumption-based emissions as there are limited avenues and reliable data sources to account for industrial process and product use (IPPU) related actions.

Table 4.4.3: NDCs in Industry Sector

NDC #	NDCs and Actions	Timeline
NDC 1	**Continue fuel-switching to sustainable biomass energy and improve user efficiency in selected industrial sub-sectors (tea, rubber, apparel, hotel & tourism, rice processing)**	**2021-2030**
	1.1 Convert industry furnaces to steam boilers and hot-water systems	2021-2030
	1.2 Improve biomass user efficiency by increasing feedstock quality, operation and maintenance practices, system design and automation	2021-2030
	1.3 Introduce biomass "Co-generation" in industries	2021-2030
	1.4 Switch from fossil fuel to biomass energy in government institutions for thermal energy requirements	2021-2030

[15] Annual Survey of Industries (2018) published by the Department of Census and Statistics.

NDC 2	**Enhance the application of Resource Efficient Cleaner Production (RECP) practices in selected industrial sub-sectors**	**2021-2030**
	2.1 Conduct RECP and energy audits and develop baselines based on industry classifications & the importance	2021-2023
	2.2 Adopt RECP practices including low carbon technologies and processes	2021-2030
	2.3 Improve water use efficiency in selected industrial subsectors	2021-2030
	2.4 Promote energy-efficient appliances and technologies such as High-Efficient Motors (HEM), Variable Frequency Drives (VFD), efficient chillers and refrigeration technologies	2021-2030
NDC 3	**Establish eco-industrial parks and villages**	**2021-2030**
	3.1 Transform existing industrial parks (IPs) incorporating maximum possible green industrial concepts	2021-2030
	3.2 Introduce policy and regulatory regime, including guidelines to ensure all new IPs will be set up as Eco IPs	2021-2023
NDC 4	**Introduce Circular Economy concept to selected industrial sub-sectors and selected industrial zones**	**2021-2030**
	4.1 Conduct a survey to identify and determine the potential subsectors to implement the circular economy concept	2021-2023
	4.2 Introduce the life cycle approach for selected subsectors for greening the supply chain	2021-2030
	4.3 Practice industrial symbiosis concept in selected industrial parks and industrial sub-sectors	2021-2030
	4.4 Establish a pilot project on the zero-waste concept in selected industrial parks or industrial subsectors	2021-2025
	4.5 Adopt ISO standards for the circular economy concept (ISO/TC 323)	2021-2030
	4.6 Build industry capacity to adopt the circular economy concept	2021-2030
NDC 5	**Introduce tri-generation facilities to selected industrial parks**	**2021-2030**
	5.1 Carry out a rapid assessment of tri-generation potential in 10 industrial parks	2021-2023
	5.2 Carry out a detailed assessment in one of the BOI industrial parks for piloting	2021-2022
	5.3 Develop business models and funding options	2021-2023
	5.4 Implement one Tri-generation facility as a pilot project	2021-2027
	5.5 Depending on the success of the pilot project, expand it into BOI and other industrial parks and other prospective applications	2021-2030
	5.6 Make provisions through policy instruments to have Tri-generation for new industrial zones	2021-2030
NDC 6	**Incentivize GHG reduction of clinker production in the cement industry**	**2021-2023**
	6.1 Make necessary amendments to Sri Lanka Standard Institute (SLSI) standards for cement production enabling the increase of ash and other similar materials as substitutes for clinker in line with industry standards and trends worldwide	2021-2023
NDC 7	**Generic enabling activities**	**2021-2023**
	7.1 Facilitate industries in selected sub-sectors to adopt relevant ISO systems having a focus on GHG emissions reduction	2021-2023
	7.2 Introduce and promote suitable tax incentives to promote the acquiring of sustainable technologies	2021-2023
	7.3 Facilitating the entry of ISO certified companies to the Green Public Procurement system of Sri Lanka	2021-2023
	7.4 Facilitating transformational investment and favorable loans through financing institutions linking with green financing	2021-2023
	7.5 Introduce a national policy to address siting of industrial parks and stand-alone industries, new concepts like circular economy, industry ecology, RECPs, digitalization, etc.	2021-2023
	7.6 Ensure the availability of sustainable biomass for industry use	2021-2023
	7.7 Promote National Green Reporting System (NGRS)	2021-2023

It is expected that the updated NDCs for 2021 to 2030 will reduce GHG emissions against the BAU scenario by 7% in the industry sector (4% unconditionally and 3% conditionally) equivalent to an estimated mitigation level of 2,088,000 MT unconditionally and 1,482,000 MT conditionally (total of 3,570,000 MT) of carbon dioxide equivalent during that period (Figure 4.4.3) . It should be noted that there are additional emission reductions from various initiatives which are difficult to be accounted for as no systematic reporting/accounting arrangement is yet in place.

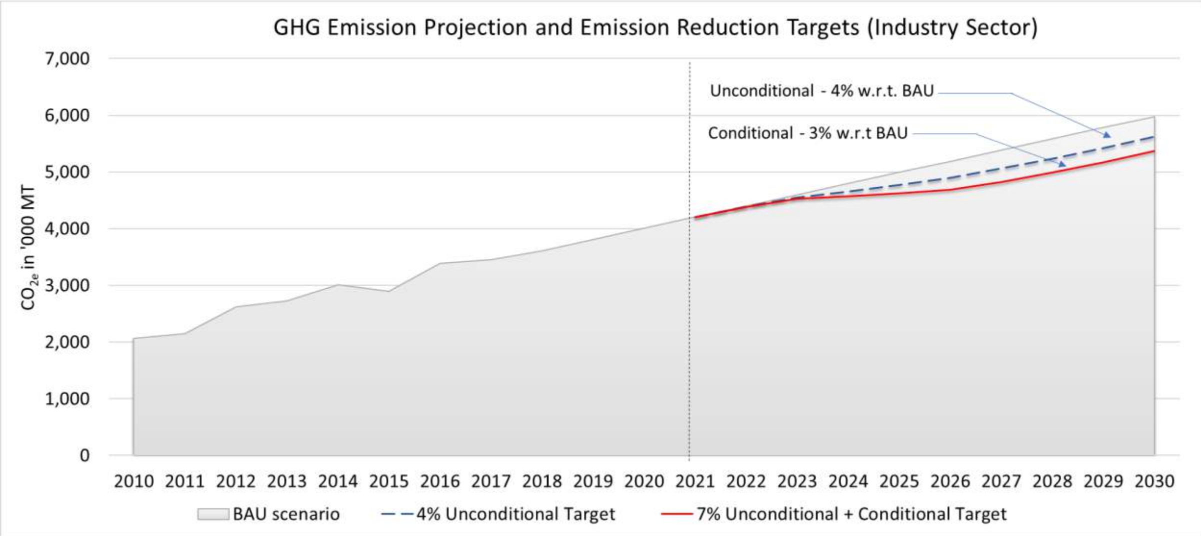


Figure 4.4.3: Emission reduction projections (Industry Sector)

4.4.4 Waste Management

Sri Lanka generates around 9,000 metric tonnes (MT) of municipal solid waste (MSW) per day (equivalent to about 0.41 kg/capita/day[16]) with the Western Province accounting for 3,500 MT (40%) of volume. Waste collection by local authorities is about 55% in the Western Province and 25% in the other provinces. With population growth, fast development of infrastructure, rapid urbanization, industrial growth, increase of per capita income, rise in living standards, changing lifestyle, and economic conditions, the generation of municipal solid waste is expected to increase in the next decade 2021-2030. This illustrates the need for a national action plan for solid waste management, that all stakeholders can acknowledge and work towards a common goal. The limited coverage of proper waste segregation and adequate waste collection mechanisms covering the whole island, inadequate public commitment on waste management, and practical difficulties in the application of 3R principles are some underlying issues of the current waste management practice.

Sri Lanka has a legislative and institutional framework with environment-related policies, strategies, and guidelines on waste management. Technologies and methods used for waste management are well accepted, however innovative technologies and strategies are yet to be introduced to streamline and modernize existing waste management practices.

The Waste Management Authority of Western Province (WMAWP) has prepared targets for waste treatment and disposal for the period 2019 to 2023. Accordingly, open dumping of waste will be significantly reduced, and waste will be collected in closed enclosures for mass disposal in respective local authorities and used in waste-to-energy projects after resource recovery steps. Already, two private companies have been granted permission for waste-to-energy generation projects with capacities of 700 and 500 MT/day and the first plant has been just commissioned. In parallel to the plan of the WMAWP, three large-scale compost facilities are in operation, each with 100 MT/day capacity. Presently, about 2% of the waste collected by local authorities is recycled, while the amount recycled by the informal sector is considered to be much higher. The Ministry of Provincial Councils and Local Government plans to establish composting facilities each with the capacity of 50 MT/day in many provinces.

Future Outlook & GHG Emissions Reduction Potential in Waste Sector: The prioritized objectives of the recently approved National Policy on Waste Management (2019) are waste avoidance and reduction. The next level of management recommends adoption of waste recycling and other forms of environmentally-sound disposal; re-use of unavoidable waste to the extent possible; maintain hazardous substances in waste at the lowest possible level and guarantee an environmentally sound residual waste treatment and disposal underlining the gradual shift from a waste generating socio-cultural regime to a new paradigm in which waste disposal is minimized in favour of reuse and reduced consumption.

Along with other measures, awareness through education and attitude change among the public is required to realize a sustainable waste management system. A long-term solution that addresses the issue of open dumping and create economic/fiscal disincentives for waste generation is needed. These NDCs (Table 4.4.4) will enhance mitigation ambitions while embracing circular economy concepts clearly spelt out in the national policies for Waste Management and Sustainable Consumption and Production.

[16] This is based on the judgement of experts of relevant authorities and various studies carried out in the past

Table 4.4.4: NDCs in Waste Sector

NDC #	NDC and Action	Timeline
NDC 1	**Improve "Circular economy'' practices in all MSW generation sources**	**2021-2030**
	1.1 Prevent, avoid or reduce MSW generation by reducing the growth by 10 % and also by reducing generation growth of industry solid waste and effluent	2021-2030
	1.2 Improve the segregation of MSW at source and increase number of segregation categories	2021-2025
	1.3 Improve MSW collection and transportation system (Up to 75% on generation basis in Western Province and 60% in other provinces)	2021-2030
	1.4 Improve waste recycling to 7% on collection basis in Western Province (WP) and 5.0% in other provinces	2021-2030
	1.5 Implement regulatory framework to control high waste generating products	2021-2023
NDC 2	**Manage biodegradable waste component through biological treatments**	**2021-2030**
	2.1 Increase the present level of composting to 30% of compostable waste collected in Western Province and other Provinces	2021-2030
	2.2 Apply suitable treatment facilities for liquid waste such as central / networked sewage and wastewater treatment facilities, night soil treatment facilities for selected Local Authorities (LAs), improve the treatment and appropriate disposal of industrial wastewater, assist LAs that have facilities for feed sludge management, prepare options to use treated waste water, enhance capacities of existing treatment plants with new treatment technologies, enhance the treatment facilities for industrial sludge and introduce volume-based pricing system for liquid waste	2021-2030
	2.3 Adopt biogas technology where composting is not practically applicable	2021-2030
NDC 3	**Introduce energy recovery using non-recyclables and waste which cannot be managed by other means**	**2021-2028**
	3.1 Establish already committed two waste-to-energy generation facilities	2021-2028
	3.2 Make policy enhancement to clearly define the purpose of waste-to-energy and plan the phasing out of preferential feed-in-tariffs	2021-2023
	3.3 Regulate the establishment of new waste-to-energy facilities	2021-2025
	3.4 Introduce other thermal treatment technologies	2021-2025
NDC 4	**The use of sanitary landfills for the disposal of residual waste will be increased from the current level of 5% to 100% on weight basis**	
	4.1 Operationalize policy and regulation for siting and implementation of sanitary landfills	2021-2023
	4.2 Rehabilitate existing waste dump sites	2021-2030
	4.3 Introduce Land-fill Gas recovery systems	2021-2030
NDC 5	**Generic enabling activities**	**2021-2030**
	5.1 Update or introduce the required legislation to facilitate and enforce the implementation of NDCs	2021-2023
	5.2 Introduce a mechanism for waste generation forecasting with a tracking system to monitor the generation	2021-2023
	5.3 Introduce legislation to make segregation of waste at household level mandatory	2021-2023
	5.4 Introduce or amend necessary legal framework and instruments to initiate Market-Based Instruments (MBIs) and non-market-based instruments to incentivize and promote sustainable consumption patterns	2021-2030
	5.5 Implement "Polluter Pays Principle" for mixed waste generators	2021-2025
	5.6 Conduct awareness and capacity building programmes for behavioural changes of waste generators as well as waste management personnel	2021-2030
	5.7 Facilitate public-private-partnerships to finance waste sector NDCs	2021-2030

It is expected that the implementation of updated NDCs during the period of 2021 to 2030 will result in GHG reduction against the BAU scenario by 11% reduction in the waste sector (8.5% unconditionally and 2.5% conditionally) equivalent to an estimated GHG emissions reduction of 2,549,000 MT (1,969,000 MT unconditionally and 580,000 MT conditionally) of carbon dioxide equivalent during that period (Figure 4.4.4).

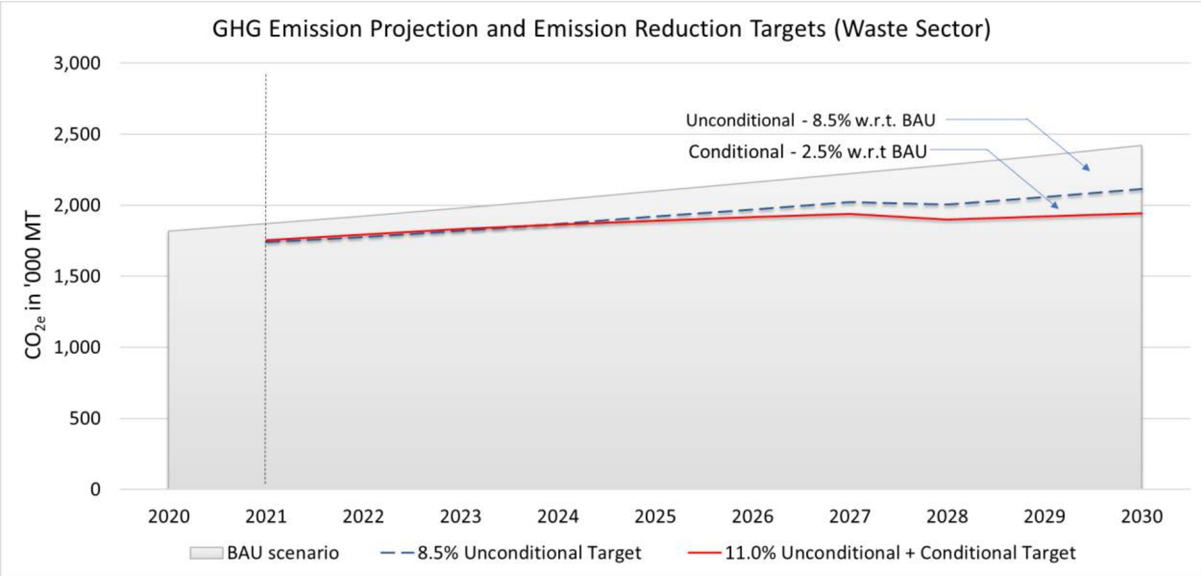


Figure 4.4.4: Emission reduction projections (Waste Sector)

4.4.5 Forestry Sector

Sri Lanka's forest cover (which was 29.15% of land area in 2015)[17] is comprised of dense forest, open and sparse forest, savannah, and mangroves.[17] This natural vegetation displays diversity and distribution under Sri Lanka's three climatic zones; Wet, Dry, and Intermediate. Furthermore, forest-like home gardens and plantations of spices, rubber, timber, etc. 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 settlement, etc.).

The main concerns for sustenance/protection of natural forests include deforestation, land degradation and soil erosion, illegal felling, wildlife poaching and mining, forest fire and degradation of coastal forests. Aside from the environmental implications, deforestation in Sri Lanka has caused landslides, soil degradation, flooding, loss of biodiversity and their habitats, pollution, etc. It is the primary threat to the survival of Sri Lanka's biodiversity.

Future Outlook & Carbon Sequestration Potential in Forestry Sector: A large number of legislative instruments, policies and strategies and programmes are in place to protect the forest cover. The Fauna and Flora Protection Ordinance (1993), Forest (Amendment) Act, No 65 of 2009, Forest Ordinance 1907 (No. 16 of 1907) as amended up to 2009, Sri Lanka Forestry Sector Master Plan 1995-2020, National Environmental Act (1980), National Action Plan for combating land degradation in Sri Lanka 2015-2024, National Biodiversity Strategic Action Plan 2016-2022, Forest Conservation and Development Plan, Sustainable Land Management Programme, the National REDD+ Investment Framework and Action Plan are the more recent of these.

The current policy framework of the government provides broad guidelines and directions for sustainable forestry management. It envisions a "Net Carbon Zero Country" and the enhancement of the natural forest cover up to 30% by 2025. There is an emphasis on identifying and reforesting suitable lands, re-establishing and enhancing green cover, restoring barren and abandoned lands for agriculture and forestry, planting trees, establishing urban forests, green paths, green roofs and agroforestry systems, establishing parks in urban and semi-urban areas, developing urban vegetation by planting trees along expressways and in industrial premises -all of which can deliver emissions reduction.

Forestry has enormous adaptation and disaster mitigation co-benefits. Forests protect catchments and ensure water availability downstream. Forests provide food and fuel for many rural communities and ensure biomass-based renewable energy availability. Nature-based solutions are proposed for many natural hazards, landslides, slope instability, flood, coastal erosion- in place of structures of cement and steel. Examples from Sri Lanka show that mangroves have protected communities from coastal degradation and forests on steep slopes have prevented landslides. Adapting traditional tree and food crops in agro-forestry systems can potentially support resilience (drought tolerance), improve food security (high nutrition fruits/food) and combat human-animal conflicts.

The following updated NDCs (Table 4.4.5) focus on carbon sequestration capacity –but the underlying premise is to improve natural forest cover and its quality by conservation of existing forests, restoration

[17] Sri Lanka's Forest Reference Level submission to the UNFCCC, 2017
https://redd.unfccc.int/files/sri_lanka___s_forest_reference_level_submission_to_the_unfccc-06jan2017.pdf

and improvement of degraded forests and establishment of new forest plantations. Engaging the private sector to enhance utility forests and commercial forestry is another option.

Table 4.4.5: NDCs in Forestry Sector

NDC #	NDC and Action	Timeline
NDC 1	**Increase forest cover[18] of Sri Lanka up to 32%[19] by 2030**	**2021-2030**
	1.1 Identify land for reforestation/forestation	2021-2022
	1.2 Develop forest management plans for natural forests to ensure sustainable management	2021-2025
	1.3 Implement forest restoration programme (18,000+ ha of non-forest lands will be reforested/afforested including mangroves)	2021-2030
NDC 2	**Improve the quality of growing stock of natural forests and plantations**	**2021-2030**
	2.1 Improve the quality of growing stock of degraded forests (200,000 ha)	2021-2030
	2.2 Improve the quality of forest plantations of 78,000 ha in state-owned lands	2021-2030
	2.3 Improve the quality of forest lands of "Regional Plantation Companies''	2021-2030
NDC 3	**Strengthen catchment protection of major rivers and cascade systems**	**2021-2030**
	3.1 Identify and prioritize multi-hazards of catchment/ river basins	2021-2022
	3.2 Strengthen lower catchment protection of 10 major rivers through tree planting	2021-2030
	3.3 Strengthen upper catchment protection of water streams running through plantations through tree planting	2021-2030
	3.4 Strengthen catchment protection of cascade systems & isolated tanks through tree planting	2021-2030
	3.5 Continue the "Climate Resilience Multi-Phase Programmatic Approach" project in lower Kelani river basin	2021-2025
NDC 4	**Improve and increase of Trees Outside Forests (TROF)**	**2021-2030**
	4.1 Adopt policy instruments and regulations supporting TROF (urban forestry, tree planting along roadside, religious premises, schools and other Government lands, home gardens)	2021-2023
	4.2 Establish an institutional setup and a mechanism to implement such programmes	2021-2024
	4.3 Conduct carbon stock evaluation for TROF	2021-2025
	4.4 Implement TROF programmes	2021-2030
NDC 5	**Generic enabling activities**	**2021-2025**
	5.1 Develop and implement a MRV system for forestry NDCs	2021-2025

It is expected that the implementation of updated NDCs of the forestry sector will result in the increase of carbon sequestration capacity by 7% against the BAU scenario (2% unconditionally and 5% conditionally) for the period 2021-2030. This is equivalent to an estimated additional sequestration of 705,000 MT unconditionally and 1,652,000 MT conditionally (total of 2,357,000 MT) of carbon dioxide equivalent during that period (Figure 4.4.5).

[18] As per the FAO definition of forests which includes forest plantations, natural forests including mangroves.
[19] 30.8% to be achieved through forest plantations and natural forests and the rest to be achieved through TROF (Trees Outside Forests)

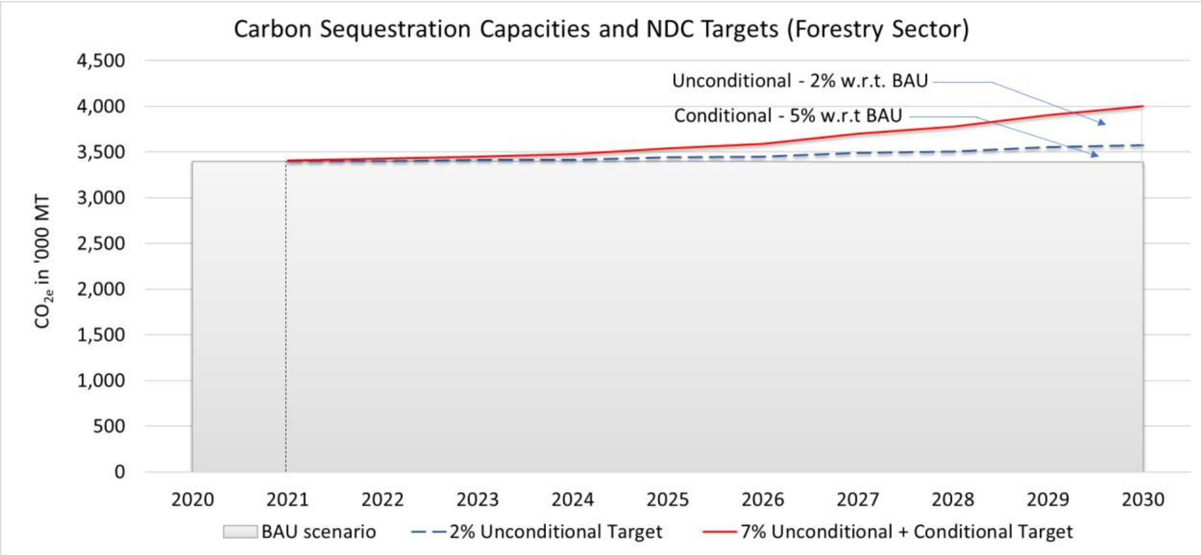


Figure 4.4.5: Carbon Sequestration Capacity Projections (Forestry Sector)

4.4.6 Agriculture Sector

Agriculture contributes around 8% of GDP and it is around 21% in export earnings[20]. The sector currently employs around 30% of the labour force. Sri Lankan agriculture comprises food crops and plantations (mainly tea, rubber, and coconut). The food crop sector is made up of small holders with average extents less than one hectare. This results in issues of diseconomies of scale and difficulty of mechanization in the face of increasing wages and scarcity of labour. Further, heavy dependence on rain-fed agriculture, lack of diversification into high-value marketable products, high cost of production/ low profitability, low-levels of technology adoption and imperfect market conditions, weak information dissemination and poor value addition are major constraints.

The Livestock sector contribution to the GDP was around 1% in 2019. The major share comes from cattle with 1.4 million animals providing 447 million litres of milk in 2019 which is equivalent to 38% of the national milk requirement. However, the livestock sector is also hindered by substandard breeding and low productivity, low adoption of technology, lack of grazing lands and high feed costs. Unproductive, feral cattle/buffalo population, poor feeding systems, poor animal welfare etc., significantly contribute to GHG emissions in the sector.

Future Outlook & GHG Reduction Potential in Agriculture Sector: The government's policy framework provides broad guidelines and directions for sustainable agriculture and environmentally conscious farming, with emphasis on modern and advanced technologies, economizing water usage, use of renewable energy, product innovations, value addition and process improvements, management of surplus production through improved post-harvest handling, packaging, transport, storing and delivery. The investments in livestock development are aimed at self-sufficiency in milk production. GHG reduction in the agriculture sector is to be achieved by implementing several key strategies. One such move is to diversify crop production away from water-intensive rice farming to more export-oriented high-value crops. Another is to improve value addition and better integrate small-holder farmers into modern agricultural value-chains reducing crop wastage. Improved technology, modern agricultural practices and waste management in both crop and livestock sectors are considered important strategies for cleaner production in this sector. The Overarching Agriculture Policy (OAP) which is being formulated will focus on improving productivity, self-sufficiency, and safety of food.

Table 4.4. 6: NDCs in Agriculture Sector

NDC #	NDC and Action	Timeline
NDC 1	**Reduce post-harvest losses and value addition of fruits and vegetables**	**2021-2030**
	1.1 Planning of cultivation management	2021-2030
	1.2 Improve post-harvest management	2021-2030
	1.3 Managing excess production	2021-2030
	1.4 Product innovation	2021-2030
	1.5 Monitoring of post-harvest management process	2021-2030
	1.6 Introduce policy and other support instruments	2021-2030
NDC 2	**Increase crop productivity**	**2021-2030**
	2.1 Identify crops with high productivity improvement potentials	2021-2030
	2.2 Adopt Good Agricultural Practices as a mandatory requirement in productivity enhancement programs of food crops	2021-2030
	2.3 Increase rice / paddy sector land-use productivity (paddy yield tons/ha) by 10% unconditionally and 5% conditionally	2021-2030

[20] https://www.cbsl.gov.lk/en/statistics/statistical-tables/external-sector

	2.4 Improve fertilizer use-efficiency by 10% unconditionally and 5% conditionally	2021-2030
	2.5 Improvement of water use efficiency	2021-2030
	2.6 Promote precision agriculture	2021-2030
NDC 3	**Improve adoption of renewable energy for crop farming/value addition**	**2021-2030**
	3.1 Application of solar PV and wind energy (or hybrid) for agriculture practices	2021-2030
	3.2 Promote grid electricity use in place of fossil fuel driven engine powered pumps	2021-2030
	3.3 Renewable energy powered mini grid for clustered agriculture farming in vulnerable areas (as a pilot)	2021-2030
	3.4 Explore and develop small hydro power potential in irrigation water canals for agriculture purpose	2021-2030
NDC 4	**Improve dairy sector productivity by managing herd, herd health, feed and by improving animal comfort and welfare** (40% increase of milk yield per cattle by 2030 on unconditional basis and further increase up to 55% on conditional basis. Increase productive milking cow percentage of the herd up to 40% on conditional basis)	**2021-2030**
NDC 5	**Improve productivity of Monogastrics by improving genetic, feed efficiency, animal health, comfort and welfare**	**2021-2030**
NDC 6	**Adopt renewable energy for livestock applications** E.g. small-scale solar-powered refrigeration to increase the milk storage facilities, solar-powered can-coolers for milk producers, solar energy for milk collection, chilling centres, farm operation and processing; and introducing biogas digesters for large scale livestock & poultry, dairy processing and abattoirs	**2021-2023**

It is expected that the implementation of updated NDCs during the period of 2021 to 2030 will result in the reduction of GHG emissions against the BAU scenario by **7%** in the agriculture and livestock sector **(4% unconditionally and 3% conditionally)** equivalent to an estimated mitigation level of 2,477,400 MT CO_{2e} unconditionally[21] and 1,858,000 MT CO_{2e} conditionally (total of 4,335,400 MT CO_{2e}) of carbon dioxide equivalent during that period (Figure 4.4.6).

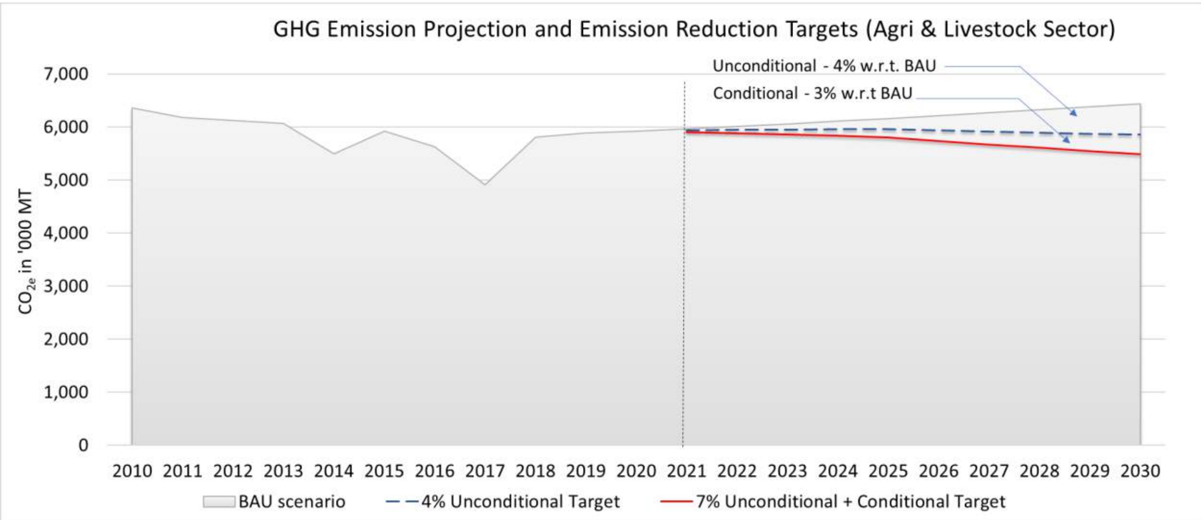


Figure 4.4.6: Emission Reduction Projections (Agriculture and Livestock)

[21] In the absence of country specific emission factors, the analysis has been based on IPCC 2006 standard emission factors provided for the agriculture and livestock sector which may not accurately represent the country context. Any correction requirement will be made during future communications as required.

Chapter 5: Adaptation NDCs

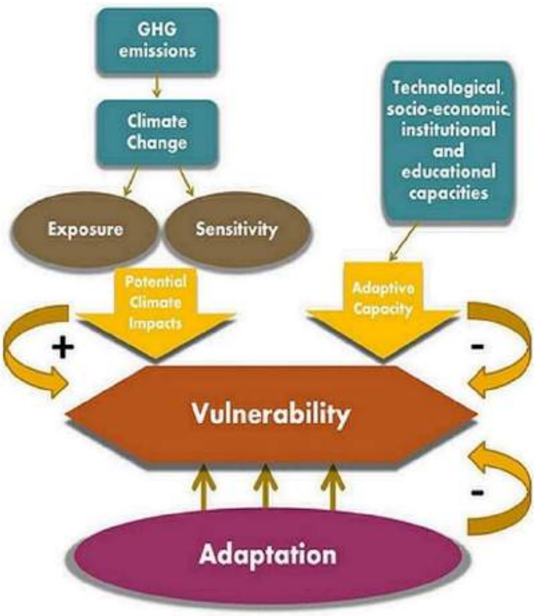
Sri Lanka's vulnerability to climate change is well documented[22] and has been presented through national communications to the UNFCCC. Recent vulnerability analysis confirms Sri Lanka's enhanced exposure to climate change parameters. These analyses point to long term changes in rainfall distribution and shifting of ecological boundaries, compounding already observable shifts of the bi-modal monsoon pattern, rainfall intensities and dry periods, the increasing temperature and heat, increasing exposure to climate hazards and sea-level rise. The most critical sectors affected by these changes are agriculture, fisheries, livestock, water, biodiversity, coastal and marine, health, urban planning and human settlements and tourism and recreation. These NDCs present prioritised actions for adaptation identified by related national agencies, experts and other stakeholders in each vulnerable sector.

Climate change poses a serious threat to economic growth and erodes development gains. The long-term policy goal for Sri Lanka is to ensure that the country is protected from adverse impacts of climate change[23]. The objective is to facilitate sustainable development in each sector in a way that supports continued economic growth and high human development while protecting the natural resource base on which many of these livelihoods are dependent.

Adaptation priorities outlined below have common underlying requirements for effective implementation. Sector-specific risk information and assessments and localised modelling tools are not widely available for decision-making. Indeed, many sectors and areas require greater availability of data at a disaggregated, local level to make accurate risk-informed investments. An example is the level of accuracy of the information available to make predictions on sea-level rise in Sri Lanka. Risk assessments for developing sectoral strategies (e.g. tourism) and for spatial development (e.g. urban centers) are currently unavailable at the required resolution, therefore have been mentioned as priority adaptation actions. Risk and vulnerability information scaled-down to sub-national level to enable decision making at provincial, river-basin or divisional level are currently not widely available.

---

[22] Global Climate Risk Index 2020 | Germanwatch.
[23] National Climate Change Policy (2012)



Adaptation actions reduces vulnerability to climate change and manages risk to life, property, well-being and key economic sectors. Sri Lanka's adaptation NDCs are designed to intervene at two levels to reduce climate change vulnerability. Firstly, by designing actions that reduce the sector or geography's sensitivity to climate change. Secondly, by increasing adaptive capacities through technological, institutional and information-based interventions, specific to the sectors at risk (as illustrated in figure.5 .1)

The sectoral NDCs described in this section support immediate adaptation needs for Sri Lanka and have been refined from the initial NDC submission in 2016 to reflect emerging needs for downscaled risk information, climate data, planning and prioritizing tools and better technology and financing for urgent adaptation.

Figure 5.1: Climate impacts, adaptive capacities, and vulnerabilities to adaptation actions[24]

Mainstreaming gender and social safeguards into adaptation priorities is an important strategy. Therefore, it is recommended that down-scaled risk assessments and sectoral plans integrate specific needs, vulnerabilities and capacities of women, young children, disabled and elderly populations. Gender- responsive strategies will take in to account the differentiated needs of men and women within the sector and recommend ways to improve access to knowledge, technology, financing etc in a way that creates enabling conditions for adaptation. Increased capacities among both men and women, improved technical and Science, Technology, Engineering and Mathematics (STEM) education, more funding for vulnerability analysis at the local level etc., to enable greater engagement and contribution of women, allowing the application of skills and capacities that are gender-specific.

In order to ensure adaptation, NDCs should enable contribution by women as well as provide equal access to benefits., the sector will need to invest in gender-responsive training, promote more entrepreneurial skills among women and provide access to technology and finance that supports their participation. Gender-responsive NDCs will enable men and women to equally benefit from new technologies, climate-smart production and water management practices that would include better agriculture productivity, food security and incomes, greater resource management efficiency (water, land, food processing and preservation) etc. As described in section 7.1, it is recommended that sectors undertake detailed gender analysis as part of the process of developing the 10-year NDC implementation plans.

Traditional knowledge in crop types, cropping systems, water management, food preparation and preservation will be important to build resilience in key sectors such as agriculture and food security, water and forestry. Traditionally used but commercially ignored species can be effectively used to improve food security, access, better nutrition, improve biodiversity outcomes and provide local options for forestry and trees outside forests (home gardens, roadsides, boundary fencing etc). Women play a

[24] Source: Stéphane Isoard, Torsten Grothmann and Marc Zebisch, Paper presented at the Workshop 'Climate Change Impacts and Adaptation in the European Alps: Focus Water', "Climate change impacts, vulnerability and adaptation: Theory and Concepts", 2008 at UBA Vienna

key role as repositories of such knowledge and can be mobilized to improve nutrition, food preservation and food storage with such information.

The United Nations Framework Convention on Climate Change (UNFCCC) identifies three forms of climate change-induced population movement: displacement, migration, and planned relocation. Migration, permanent or seasonal, has clear interlinkages with the enhanced vulnerability of rural populations exposed to continued climate disasters. It is critical to study the phenomenon of migration to determine the extent of the problem, challenges of enhanced vulnerability for both rural and urban poor) and the rights of those displaced from their homes and uprooted from livelihoods due to exacerbated climate crisis. Increased availability of data and information on climate migration is critical for evidence-based interventions in this regard. Migration related analysis should be included in adaptation sectors, especially agriculture, health, and urban settlements.

There are several sectors where the stated adaptation priorities contribute towards GHG emissions reduction. Such reductions are expected in the urban planning and human settlement sector (sustainable and green building design, and increased tree cover), water sector (energy efficiency and reduced pumping) and tourism sector (energy efficiency and green buildings).

Financing needs for adaptation are enormous and cannot be born solely through public investment. Sri Lanka has over the year accessed climate financing from climate funds, bilateral and multilateral agencies. However, this access has not met the country's demand for adaptation. Indication of financing requirements for adaptation sector resilience building will be expected to be indicated in National Adaptation Plan (NAP) and NDC costing exercises in the future.

5.1 Sectoral Adaptation NDCs

5.1.1 Agriculture Sector

Despite the gradual contraction of its contribution to national GDP, agriculture remains the most important economic activity in Sri Lanka. It employs over 2 million people which is around 30% of the workforce and rural districts provide income and livelihood for over half the population. Agriculture land use is approximately 2.2 million ha which is equivalent to 35% of the country's total land area. A large extent of this land is owned by smallholder farmers, contributing to a major share of annual crop production. The plantations (tea, rubber, coconut, spices, coffee) are confined to the Wet/Intermediate Zones of the country and significantly contributes to the country's export earnings.

Sri Lanka's fiscal policies favour agricultural expansion and productivity with the objective of self-sufficiency in as many crops as possible, reiterated in 2020 through new regulations controlling agricultural imports. The Government's vision[25] prioritizes new technology, value addition and efficient storage and transportation, reducing chemical inputs, promoting more sustainable models of agriculture, reducing food importation costs and earning increasing export revenue through agriculture. An Overarching Agriculture Policy (OAP) is under development and will embrace all key agriculture sector institutions from crop, livestock, inland fishery, agro-processing, and allied services such as irrigation, agrarian development, and environment. This new policy will encompass the National Agriculture Policy (2007) which is also being updated, National Agricultural Research Policy (2012), National Livestock Development Policy (2007), and the aspects related to inland fisheries of the National Fisheries and Aquatic Resources Policy (2018).

[25] Vistas of Prosperity and Splendour, Ministry of Finance 2019

Climate risks in the Agriculture Sector: Climate change impacts on agriculture has been studied and recorded in somewhat greater detail in Sri Lanka. Temperature increase and high evaporation rates are expected to affect the staple crop- rice. Meteorological records point to 283 dry spells over the period of 30 years since 1974. Erratic and unseasonal rainfall and unpredictability of the monsoons severely impact agriculture (both flooding and drought impacts on crops including paddy) livelihoods and socio-economic conditions of rural smallholders, undermining some of the investments made by the government on agriculture and irrigation. Furthermore, temperature anomalies (lack of cold nights, especially) affect high-value crops, such as upcountry vegetables. Plantations of tea and coconut are affected by long dry spells and rubber by intense rainfall. Tea productivity fell to a 25 year low in 2020 due to longer dry spells in the plantation regions. Lack of rainfall coupled with human-induced activities stoke forest fires and hasten the drying up of streams and water sources. Sea level rise induced salinity is expected to impact coastal agriculture. The Third National Communication to the UNFCCC[26] highlights the need for more climate risk related research on crops being currently promoted among farmers such as cinnamon and pepper.

Adaptation in the Agriculture Sector: Resilience building in the agriculture sector is organized under six NDCs (Table 5.1.1) including mainstreaming of climate change considerations into the sector, varietal improvement to address climate vulnerability, sustainable land and water management and enhanced early warning climate risk management. Contribution to the reduction of greenhouse gasses from postharvest losses, enhanced efficiency in production and adopting renewable energy in production processes of the agriculture sector is presented in the Agriculture Sector Mitigation NDCs.

Table 5.1.1: NDCs in Agriculture Sector

NDC #	NDCs and Actions	Target Year
NDC 1	**Climate change considerations mainstreamed into agriculture in Sri Lanka**	**2022**
	1.1 National Guidelines on Climate Smart Agriculture (CSA) produced and implementation commenced	2021
	1.2 Climate change resilience building introduced into the criteria for Sri Lanka Good Agriculture Practices (SL GAP) guidelines	2021
	1.3 Promote appropriate crop-livestock integrated farming systems in climate vulnerable regions	2022
	1.4 Promote home gardens as small-scale production systems with value addition and establishment of market channels	2022
NDC 2	**Promote Integrated Pest Management (IPM) and Integrated Plant and Nutrition Systems (IPNS) in most vulnerable areas/districts/crops**	**2025**
	2.1 Identify priority areas of vulnerability to resurgence and emergence of pests/disease, weeds and wild animal attacks due to climate change	2021
	2.2 Develop and introduce appropriate IPM and IPNS programmes for the priority areas	2022
	2.3 Increase SL GAP Certified products by 25% from areas that are highly vulnerable to climate change	2025
NDC 3	**Develop/introduce varieties resistant/tolerant to biotic and abiotic stresses targeting most vulnerable agricultural crops to climate change**	**2030**
	3.1 Develop, introduce/promote heat tolerant varieties	2030
	3.2 Develop, introduce/promote drought tolerant/escape varieties	2030
	3.3 Develop, introduce/promote excess soil moisture/flood tolerant varieties	2030
	3.4 Develop, introduce /promote salt tolerant varieties	2030
	3.5 Develop and promote pest and disease resistance /tolerant varieties	2030
	3.6 Develop, introduce fodder varieties that withstand extreme climatic conditions	2030

[26] Third Nation Communication to UNFCCC, Climate Change Secretariat, (draft).

NDC 4	**Revisit the Agro Ecological Regions (AERs) maps of Sri Lanka with current and future climate scenarios and recommend appropriate crops for different regions to reduce vulnerability to climate change impacts**	**2030**
	4.1 Expanding the Agro-met observation network to cover the most vulnerable AER to climate change	2025
	4.2 Conduct studies related to soil moisture regimes covering most vulnerable AER to climate change	2028
	4.3 Most vulnerable AERs are re-demarcated into sub zones to make recommendations for specific crops	2030
NDC 5	**Enhance sustainable land and water management practices in areas where anticipated climate vulnerability is severe**	**2030**
	5.1 Promote input efficient farming methods / systems covering the target area by 50% in 2025 and 100% by 2030	2030
	5.2 Promote farm rainwater harvesting to cover the target area by 75%	2025
	5.3 Promote storm water management in 25% of the target area	2025
	5.4 Promote crop diversification with input efficient and climate change tolerant varieties in 50% of the target area	2030
	5.5 Restoration of small tank cascades and individual tanks to cover the entire target area (links to water sector NDC 7)	2030
	5.6 Promote and apply soil conservation measures in 50% of the target area	2028
NDC 6	**Enhanced early warning and risk management mechanisms introduced to reduce climate change vulnerability**	**2025**
	6.1 Improved seasonal climate forecasting for Maha and Yala	2023
	6.2 Promote provision of simplified and timely communication to farmers and field-level officials in agriculture	2025
	6.3 Strengthen risk management and risk transfer mechanisms in agriculture	2025
	6.4 Strengthen early warning systems/advisory for climate hazards and pest and disease risks	2025
	6.5 Introduce climate-related crop forecasting to reduce post-harvest losses	2025
	6.6 Promote protected agriculture and other technologies for climate risk management	2025

5.1.2 Fisheries Sector

Sri Lankan fisheries sector covers marine, coastal, inland fishery and aquaculture. Marine fishery covers 517,00 km^2 sea area while coastal and inland fisheries use 489,000 ha of lagoons, estuaries, reservoirs and riverine areas[27]. Marine and coastal fishery contributes 80% of the total fish catch and provides 2.4 million direct and indirect employment and 70% of the animal protein intake of the populace. Fishery contributes approximately 1.2% to Sri Lanka's GDP[28]. There is great potential to develop the sector, with new technology, value addition and aquaculture development. Ministry of Fisheries and Aquatic Resources Development and Department of Fisheries & Aquatic Resources (DFAR) takes charge in guiding the sector development with its National Fisheries and Aquaculture Policy, 2018 and regulations framed under the Fisheries and Aquatic Resources Act No 2 of 2016 and its amendments.

The national policy framework[29] indicates achieving better nutrition, food security, foreign exchange earnings, employment and livelihood opportunities, poverty alleviation and enhanced contribution to the national and rural economy as its objectives for the fisheries sector.

Currently, unsustainable fishery practices, over-fishing of certain species, poaching, land-based pollution from rivers, garbage dumping and habitat destruction in coastal areas (mangroves and coral reefs) are the main threats to Sri Lanka's fishery resources.

Climate risks in the Fisheries Sector: Ocean warming, and acidification is already threatening global fishery. These risks will be exacerbated by future warming. Long-term changes in the marine eco-system will change species distribution. Climate change will alter mangrove and seagrass ecosystems which support breeding grounds for commercially viable fish species. Loss of wetlands in coastal areas, changes in the salinity of lagoons and estuaries affecting fish and shellfish will be greatly felt. Ocean acidification would make it more difficult for shellfish, crabs, lobsters and corals to build calcium carbonate shells, resulting in diminished stocks. Risks are greater if warming reaches beyond 1.5°C with substantial losses predicted for coastal livelihoods and fishery related industry[30]. In Sri Lanka, shrimp farming on the north-west coast was found to be particularly vulnerable in a recent assessment[31]. Inland fishery is threatened by changes in temperature, droughts, precipitation, run-off and floods on freshwater ecosystems. Risk on inland fisheries would be further aggravated by projected decreased rainfall during North-East Monsoon.

Secondly, increasing natural disasters such as storm surges and high winds/cyclones will cause damage to reefs and thereby increase coastal erosion and salinity of inland soil and freshwater sources. Properties and physical infrastructure of small-scale fishers and their communities would also be threatened with increased frequency of climate-related disasters as well as rising sea levels and creeping salinity in coastal areas.

Adaptation in the Fisheries Sector: Adaptation measures are organized under seven NDCs (Table 5.1.2) including adopting ecosystem-based approaches to fisheries management, expansion of aquaculture and culture-based fisheries for enhanced food security, breeding species for aquaculture to withstand adverse climatic conditions, enhanced safety at sea, better early warning for climate risk management, livelihood diversification and targeted research on impacts on fisheries due to climate change.

[27]Fisheries Statistics 2019, Ministry of Fisheries and Aquatic Resources Development, 2019.
[28] Annual Report 2019, Central Bank of Sri Lanka, 2019.
[29] Vistas of Prosperity and Splendor, Ministry of Finance, 2019
[30] IPCC website, https://www.ipcc.ch/reports/
[31] Sri Lanka's Third National Communication on Climate Change, Climate Change Secretariat of the Ministry of Environment, 2021.

Table 5.1.2: NDCs in Fisheries Sector

NDC #	NDCs and Actions	Target Year
NDC 1	**Ecosystem-based Approach to Fisheries Management (EAFM) adopted in areas of high climate vulnerability to enhance resilience**	**2030**
	1.1 Incorporate EAFM into existing fisheries management areas as declared under Fisheries and Aquatic Resources Act	2022
	1.2 Identify priority areas and define fisheries management units based on ecological principles	2022
	1.3 Develop 5 EAFM plans	2025
	1.4 Implement 5 EAFM plans	2030
NDC 2	**Expand aquaculture and culture-based fisheries to address food security issues relating to climate change**	**2025**
	2.1 Promote an appropriate fish fingerling stocking programme for enhancement of culture-based fisheries	2025
	2.2 Establish fish barricade devices for 50 perennial reservoirs impacted with frequent floods to prevent fish escape, in consultation with Irrigation Department	2022
	2.3 Promote culture of species that are resilient to climate change	2025
NDC 3	**Breeding of climate change resilient and commercially important aquatic resources**	**2025**
	3.1 Expansion of cryopreservation facility at NAQDA, aquaculture center at Dambulla to stock the sperms of the species whose normal spawning is affected by climate change	2025
	3.2 Establish new fish breeding units with indoor hatchery facilities and design constructions enabling control of temperature and salinity for breeding tolerant strains of selected species	2025
NDC 4	**Increase the production capabilities of fisheries, aquatic resources in 30 lagoons that are highly vulnerable to climate change**	**2030**
	4.1 Identify vulnerable lagoons (by 2022) and prepare lagoon profiles for 30 lagoons	2026
	4.2 Carrying capacity assessment of 30 lagoons	2026
	4.3 Declaring and managing 10 lagoons as Co-managed Fishery Management Areas (FMAs)	2030
	4.4 Minimize aquatic pollution in 10 lagoons	2030
	4.5 Promoting aquaculture of selected climate change resilient, high value food species in selected lagoons.	
NDC 5	**Enhanced safety at sea against climate change influenced extreme conditions**	**2025**
	5.1 Promote applicable measures to enhance safety at sea	2022
	5.2 Introduce effective early warning transmission systems for fishers (including small boats and traditional crafts) and insurance schemes	2025
	5.3 Establishment of an efficient weather information management and communication system including satellite-based vessel monitoring system to ensure safety at sea	2025
NDC 6	**Diversification of livelihoods of fisherfolk to build resilience to climate change**	**2025**
	6.1 Enhance access to credit, inputs training for diversification of livelihoods of the vulnerable fisherfolk	2023
	6.2 Assist in finding high- value markets to deal with reduced yields	2024
	6.3 facilitate value additions through diversification of fisheries related products (fish oil, fish sauce and other value-added products)	2025
NDC 7	**Conduct fisheries and aquatic resources research to build resilience to climate change**	**2030**
	7.1 Assess climate impacts on fisheries and aquatic resources	2025
	7.2 Develop reef monitoring systems to provide early warning alerts of bleaching events	2025
	7.3 Identify adaptation measures in fisheries for ocean acidification related impacts	2025
	7.4 Installation of artificial reefs where substrate for settlement of corals larvae is minimal	2025
	7.5 Deployment of fish aggregating devices in identified areas	2030
	7.6 Reduce capital, operation and other costs in fisheries and aquaculture by introducing and promoting fuel- efficient technologies in response to declining yield and productivity in a changing climate	2025

5.1.3 Livestock Sector

The livestock sector is a key contributor to food security and agricultural development also supports poverty alleviation. In Sri Lanka, livestock rearing is mostly managed at small-scale and provides additional income and livelihood support for rural, agricultural households utilizing excess labour, underutilized agricultural by-products and marginal lands. Livestock has shown a nominal growth in the last few years and sector contribution to the GDP is around 1%.[32] Cattle farming takes the major share with some 1.4 million animals providing 38% of the national milk requirement in 2019. Poultry is the next major subsector producing chicken meat (225,000MT in 2019) and eggs (2 billion) in 2019.[33] However, the cost of production of both chicken meat and eggs have increased due to low productivity. Beef production is on the decline while pork and mutton production was on the rise in recent years.

The government proposes to enhance the milk production from the present 40% of the requirement to self-sufficiency, development of quality grasses for livestock and improving poultry production for the export market. The National Livestock Development Policy (2007) and the *Livestock Master Plan - A Strategy for Livestock Development towards Self-sufficiency* (2011) provide policy guidance to the sector. With the other agencies under the Ministry of Agriculture, the Department of Animal Production and Health takes the lead in improving the livestock sector development in Sri Lanka. *National Livestock Breeding Policy Guidelines and Strategy for Sri Lanka*, (2010) has been the main guidance for livestock breeding. The Overarching Agriculture Policy (OAP) under preparation is expected to provide the policy framework for all key agriculture sector institutions -crop, livestock, inland fishery, crop processing, and allied services such as irrigation, agrarian development and environment.

Climate risks for the Livestock Sector: Globally it is estimated that there will be a loss of livestock rangelands of around 10% if temperatures rise to 2°C of warming.[34] In Sri Lanka, animal production sub-sectors such as dairy, poultry and swine have been assessed for heat stress and exposure to climate related disasters such as flood and drought. Increasing temperature and the associated water scarcity is the most pressing threat for the livestock industry. Dairy is by far the most important and most threatened by temperature rise. Intensification of dairy systems in dry regions using temperate breeds could lead to greater vulnerability to temperature and humidity increases. The Temperature Humidity Index (THI) is predicted to be greater than 72 units in most areas of the Dry Zone in 2030 and heat stress will be detrimental to the industry if temperate breeds are used. There is some threat from flash floods (north-western, western and southern provinces) and prolonged drought, especially in the Dry Zone (north, north-west and eastern provinces).

Adaptation in the Livestock Sector: Livestock sector adaptation priorities are presented under three NDCs (Table 5.1.3) covering climate resilience building in ruminant livestock farming practices, in managing swine and poultry farms, and sector-wide research and development, training and capacity building to adapt livestock practices to climate change. Contribution to the reduction of greenhouse gasses from enhanced efficiency and adopting renewable energy in the livestock sector is presented in the Agriculture Sector Mitigation NDCs.

[32] Annual Report 2019, Central Bank of Sri Lanka, 2019.
[33] Livestock Statistical Bulletin 2019, Department of Animal Production and Health, 2019.
[34] IPCC website, https://www.ipcc.ch/reports/

Table 5.1.3: NDCs in Livestock Sector

NDC #	NDCs and Actions	Target Year
NDC 1	**Introduce adaptation measures to address adverse impacts of climate change on ruminant livestock**	**2025**
	1.1 Identify and promote appropriate adaptation measures, technological innovations and resilient farming systems including heat stress management	2022
	1.2 Promote integration of rainwater harvesting ponds into medium and large farms	2023
	1.3 Introduce adaptation measures such as forage conservation, modification of feeding systems to respond to early warning on extreme weather events	2023
	1.4 Introduce/ develop high yielding and climate adaptable new forage and feed resources	2025
	1.5 Continuous monitoring/ improved surveillance by veterinary services to detect and respond to new/re-emerging climate-related diseases	2022
NDC 2	**Introduce technological innovations and interventions to build resilience in poultry and swine farming**	**2025**
	2.1 Facilitate small-scale operators to adopt climate-resilient housing and management practices to prevent heat stress	2023
	2.2 Continuous monitoring/ improved surveillance by veterinary services to detect and respond to new/re-emerging climate-related diseases in poultry and swine	2023
	2.3 Promote more widely, existing adaptation measures such as feed conservation, modification of feeding systems to manage available feed in responding to early warning systems on extreme conditions	2025
NDC 3	**Improve research, education, awareness and capacity building for climate change adaptation**	**2030**
	3.1 Technology and knowledge transfer to implement adaptation measures, considering gender sensitivity in the livestock sector	2022
	3.2 Conduct awareness and educational programmes on climate resilience in livestock activities	2025
	3.3 Capacity building of all institutions in the livestock sector to promote resilience- building measures discussed in NDC 1 and 2	2030
	3.4 Access to risk management and financing to support adaptation to climate risks and changes	2025
	3.5 Review and revise existing training curricular in universities offering veterinary and animal production-related degree programmes and in the Department of Animal Production and Health in addressing climate vulnerability	2021
	3.6 Improve research and development to identify climate-resilient breeds/varieties and new technologies for livestock management	2022

5.1.4 Water Sector

The water sector includes water resources used for different purposes covering drinking, irrigation and water for other purposes (environment, industry, fisheries, hydropower etc.) Water security has become a serious concern in Sri Lanka amidst erratic weather patterns and increasing demand for water, prompting the need for urgent implementation of improved water management strategies across all its sub-sectors. Government initiatives such as Mahaweli Water Security Improvement Programme, Climate Resilience Improvement Project, Climate Resilient Integrated Water Management Project, Strengthening Climate Resilience for Communities in Vulnerable River Basins, Watershed areas and downstream of the Knuckles Mountain Range and Surakimu Ganga (protect our rivers) are some of the notable ones addressing water security amongst many other.

Authorities are increasingly considering Integrated River Basin Management (IRBM) approaches where water security can be enhanced and balanced between the competing uses of water. Therefore, in these NDCs, the previously (2016 NDCs) individually dealt domestic water (named Water Sector) and Irrigation Sector are presented as a combined single sector. Other water uses covering industry, hydropower, fisheries and energy are addressed in respective sectoral NDCs. Environmental aspects of water management are partly covered under biodiversity NDCs. Furthermore, agriculture sector adaptation NDCs represent some additional measures covering water use efficiency and agricultural water management.

The *Vistas of Prosperity and Splendour*[35] highlights the provision of safe drinking water through pipe-borne schemes. Irrigation water use efficiency and use of renewable energy are also highlighted therein. The draft National Policy, Strategies and Institutional Framework for Water Resources Development, Conservation and Management will be the key guiding policy framework when it is finalized. The preparation of an Overarching Agriculture Policy (OAP) will also provide specific guidance on irrigation water use and efficiency. Strategic Action Plan for Adaptation for Irrigation and Water Resources Sector to Climate Change 2019-2025 and beyond provides adaptation action for the sector.

Climate change influenced risks to the Sector: Major risk factors relating to the water sector are expected to further exacerbate the climate change impacts. Hence the allocation of available water between users will become increasingly challenging. Climate change influenced risks to water include water scarcity in terms of quality and quantity, salinity intrusion and damage to water distribution structures by extreme events including floods, droughts and sea-level rise. These are expected to exacerbate with temperature increase and rainfall variation, especially the negative anomaly predicted for the first inter-monsoon. Districts in the Kelani, Nilwala and Walawe basins demonstrate drinking water sector vulnerability to flood events -which are more frequent due to intense rainfall events.

Salinity is an issue throughout the coastal area, but especially where demand for ground water has increased exponentially (Western Province, North Western Province & Eastern Province). Lack of water for sanitation due to drought and flood also has been identified as a health risk of significance in selected districts. The North-Western and North-Central provinces possess a large number of minor and major irrigation schemes some dating back a millennium. Prolonged droughts and changing rainfall patterns threaten the water storage in these reservoir networks. High ambient temperatures lead to high rates of evapo-transpiration from these water bodies. Over siltation due to interrupted land cover reduces the depth of these irrigation tanks aggravating water loss via pan evaporation. Meanwhile floods caused by sudden and intense rainfall events damage irrigation structures such as dams, spills, canals and

[35] National Development Framework. Ministry of Finance, 2019

sluices. In the past decade there have been many major flood events in the Dry Zone, leading to high rates of damage to irrigation structures and high rates of siltation in reservoirs.

Adaptation in the Water Sector: As outlined above, water sector adaptation to climate change is organized under two main sub-sectors covering domestic water use and irrigation water use. The main policy drive in water sector adaptation to climate change is provided by adopting Integrated River Basin Management (IRBM) approach in 15 proritised river basins in Sri Lanka. River basins prioritised were Kelani Ganga, Attanagalu Oya, Gin Ganga, Nilwala Ganga, Malwathu Oya, Deduru Oya, Ma Oya, Gal Oya, Kala Oya, Mahaweli Ganga, Mundeni Aru, Kalu Ganga, Mi Oya, Yan Oya and Kirindi Oya.

The sector has ten NDCs (Table 5.1.4) which includes one overarching NDC covering IRBM; five NDCs on domestic water use including ground water monitoring, climate-resilient water supply schemes, promoting the use of waste water, managing salinity at water intakes, capacity building for climate change adaptation; and four NDCs on irrigation water use including restoration, rehabilitation and augmentation of irrigation systems, the introduction of alternative water sources, improving irrigation efficiency and early warning for river flooding.

Table 5.1 4: NDCs in Water Sector

NDC #	NDCs and Actions	Target Year
	Water sector wide IRBM	
NDC 1	**Integrated River Basin Management (IRBM) adopted in 15 prioritised river basins in Sri Lanka**	**2030**
	1.1 River basin-wide vulnerability, risks and capacity assessments carried out in 15 river basins in Sri Lanka	2025
	1.2 Climate change adaptation considerations built into integrated river basin management planning initiatives of Sri Lanka	2023
	1.3 Water resource development and management plans for the selected 15 river basins are prepared	2030
	1.4 Integrated River Basin Management (IRBM) plans are prepared (by 2025) for at least five critical river basins and implemented (Five basins identified are Yan Oya, Mi Oya, Malwathu Oya, Gin Ganga and Nilwala Ganga)	2030
	1.5 Establish water flow and sediment load monitoring systems in five priority basins	2025
	1.6 Harness excess water in selected river basins to storage facilities elsewhere through trans-basin diversions	2030
	1.7 Enhancement of water retention/recharge in catchments using appropriate measures such as ecosystem restoration, tree planting, small ponds, check dams to enhance climate resilience	2025
	1.8 Implementation commencement of the five plans addressing climate vulnerability	2030
	1.9 Prepare remaining 10-climate inclusive river basin development plans Ten basins identified are Kala Oya, Ma Oya, Gal Oya, Deduru Oya, Mahaweli Ganga, Mundeni Aru, Kalu Ganga, Kelani Ganga, Attanagalu Oya and Kala Oya	2030
Domestic Water Supply Sub Sector		
NDC 2	**Ground and surface water monitoring in the Northern, North Central and North Western provinces and other areas of high drinking water vulnerability to drought**	**2030**
	2.1 Conduct risk assessments and contingency plans for all new drinking water projects in priority areas	2025
	2.2 Seek new water sources and options (i.e. rainwater harvesting and sub surface water) to augment water supply in areas where supply is scarce	2025
	2.3 Mitigation of drought impact by establishing provisional deep wells on risk- prone districts	2025
	2.4 Identify and implement appropriate groundwater recharge systems of the water deficit areas	2024
	2.5 Ensure water security at all times with the required quality and quantity of water	2025

	2.6 Establish sustainable extraction levels of ground water in at least three river basins (by 2025) and expand coverage by further three river basins	2030
NDC 3	**Promote climate- resilient water supply schemes**	**2025**
	3.1 Establish new technology in real- time measurements of water quality and level on major water sources in a collaborative manner with water sector institutions	2024
	3.2 Device mechanisms to supply safe drinking water during floods, droughts and during saltwater intrusion for all water supply schemes vulnerable to floods, droughts and saltwater intrusion	2024
	3.3 Strengthen interagency coordination for early warning on climate and weather-related disasters and health emergencies with timely disaster response	2025
	3.4 Innovative approaches such as Payment for Ecosystem Services (PES) to be explored for catchment protection in vulnerable regions	2025
	3.5 Establish desalination or rainwater facilities in most vulnerable areas with inadequate other sources of potable water	2024
	3.6 Minimize the level of Non-revenue Water (NRW) as a water conservation / efficiency improvement measure in all water supply schemes	2025
NDC 4	**Promote the use of wastewater for gardening, sanitary, construction and other purposes to reduce demand for treated water**	**2026**
	4.1 Some policy initiatives at the national level for use of treated water for other purposes piloting in industries, industrial parks and apartment buildings	2024
	4.2 Promotion of most appropriate mechanisms of water conservation / reusing / recycling for different purposes	2025
	4.3 Introduce by-laws and building codes to introduce reuse of wastewater in new industrial constructions including areas under industrial estates	2026
	4.4 Introduce market mechanisms for promoting above	2026
	4.5 Public awareness-raising on private and social benefits of wastewater management	2022
NDC 5	**Establish salinity barriers in 03 rivers where intakes are subjected to climate change influenced saline water intrusion during the drought season** (covering Kelani Ganga, Kalu Ganga, and Malwathu Oya)	**2030**
	5.1 Identify best solutions (covering technical and financial) for salinity barriers for each case	2023
	5.2 Establish salinity barriers at each critical river identified	2025
	5.3 Assess and establish regulatory mechanisms to manage ground water extraction in areas with salinity intrusion issue	2027
	5.4 Monitoring and recording of saline water intrusion into drinking water sources especially during drought periods	2030
	5.5 Strengthening interagency coordination in early warning of salinity intrusion and allocation of water for flushing as a priority when needed	2030
NDC 6	**Capacity building for water sector personnel and public awareness on building resilience to climate change**	**2030**
	6.1 Capacity needs assessment of the water sector institutions and the personnel on climate resilience building	2022
	6.2 Prepare plans for building capacity in each institution to effectively implement the sector NDCs including that of community water supply schemes	2024
	6.3 Awareness raising and behavioural change campaigns for the public towards sustainable use of water as a climate resilience building for water security	2025
	6.4 Capacity development in communities and Community Based Organizations in addressing climate resilience in water resources	2022
	6.5 Demand-Side Management and promotion of 3R amongst water users in most vulnerable areas for climate change	2030
	6.6 Establish accreditation schemes for water sector technicians/plumbers with awareness on climate change vulnerabilities	2022
	6.7 Supply-Side Management through enhanced efficiency in abstraction, transmission, and distribution of drinking water	2022
	Irrigation Water Sub Sector	

NDC 7	**Restore, rehabilitate and augment 25 major /medium reservoirs and 300 minor irrigation systems and 200 km length of irrigation canals of Sri Lanka for enhancing climate resilience in the agriculture sector**	**2030**
	7.1 Prioritize abandoned tanks (including small tank cascade systems) and canals to be rehabilitated in the most critical areas of climate change vulnerability paying attention to productivity gains in restoration	2021
	7.2 Prepare indicative cost estimations, means of implementation with national capacity and international support needed for the priorities for restoration	2021
	7.3 Restoration of 50 tanks and canals of 100km length with periodic (every 2 yr) targets with agencies responsible (DAD, PDoI, DoI, MASL and special projects)	2030
	7.4 Augment capacity of irrigation tanks to enhance climate change resilience covering 25 major/medium reservoirs and 50 minor irrigation systems	2030
NDC 8	**Introduce or promote alternative water resources as a climate change resilience building intervention for domestic and supplementary irrigation**	2030
	8.1 Carryout feasibility studies for use of alternative sources of water for irrigation and ground water recharge for building climate resilience	2024
	8.2 Assessment & identify priority domestic water supply and priority supplementary irrigation schemes to be supported by groundwater resources (by means of tube wells/deep wells) as a climate change resilience building intervention	2023
	8.3 Regulate provision of groundwater through Agro wells for irrigation based on water availability and safe abstraction levels	2030
NDC 9	**Enhance water management in 40 irrigation schemes**	**2025**
	9.1 Increase system water use efficiency in irrigation by 10% to cover at least 45,000ha of irrigated land	2025
	9.2 Introduce water- saving applications like micro- irrigation system (sprinkle) and low water intensive crops	2025
	9.3 Farmer training and awareness on water saving applications	2025
	9.4 Introduce efficient distribution of water among farmer organizations through better water allocation mechanisms	2025
	9.5 Promote market-based instruments for the adoption of new irrigation technologies (water Subsidy schemes and tax reliefs)	2025
NDC10	**Assess river floods and mitigation measures and early warning systems for possible flash floods for five priority basins** (covering Kelani Ganga, Attanagalu Oya, Kalu Ganga, Kirindi Oya and Malwathu Oya on pilot basis)	**2030**
	10.1 Install river and reservoir gauges and collect rainfall data and river flow data for the five priority basins	2025
	10.2 Prepare digital elevation maps for all priority basins and establish automated early warning systems	2025
	10.3 Conduct capacity building programs for newly established early warning systems associated technological applications and dissemination	2025
	10.4 Introduce flood mitigation structures to handle climate change influenced risks	2030

5.1.5 Biodiversity Sector

Sri Lanka is a global biodiversity hotspot. Species diversity, distribution and natural evolution depend on climatic and microclimatic factors and is mostly concentrated in the Wet Zone or south western quarter of the country. Change in macro-environmental parameters, especially precipitation, humidity, temperature and pH, can influence the distribution and survival of species that depend on specific habitat/micro climatic conditions and increase the threats from invasive species to sensitive habitats. Studies on several rare, endemic species detailed in Sri Lanka's Third National Communication to the UNFCCC, National Biodiversity Strategic Action Plan 2016-2022 and Technology Needs Assessment for Climate Change Adaptation show that the habitat ranges will shrink and shift for both higher plants, insects, amphibians and reptiles as temperature increases and rainfall becomes more erratic.

The national policy framework commits to biodiversity conservation including restoring and rehabilitating degraded ecosystems and integrating biodiversity conservation into tourism, education and cultural events in a planned and systematic manner. There are many policies related to biodiversity conservation in Sri Lanka. The key policies include the National Forestry Policy of 1995, the National Wildlife Policy of 2000, the National Environmental Policy of 2003, the National Policy on Invasive Alien Species (IAS) in Sri Lanka of 2016. The National Biodiversity Strategic Action Plan, 2016-2022 is the overall strategy for conserving biodiversity in Sri Lanka under the leadership of the Biodiversity Secretariat of the Ministry of Environment. The Ministry of Wildlife and Forest Conservation together with the Department of Wildlife Conservation (DWC) and Department of Forest Conservation (FD) are the key government institutions. Fauna and Flora Protection Ordinance No 22 as amended in 2009 and Forest Conservation Ordinance No 65 as amended in 2009 are the key legislature enabling the DWC and FD respectively in the conservation of biodiversity in Sri Lanka.

Climate risks in the Biodiversity Sector: There are recent studies[36] indicating a shift of ecological zones due to climate change. With a dearth of reliable data to identify vulnerable species and habitat changes, Sri Lanka's NDCs have focused on the potential impacts of the predicted shifts in climatic zones. Such changes are quite likely to bring about changes in species and habitat and could have negative impacts on the overall biodiversity of Sri Lanka, if adequate measures are not taken to identify and manage these changes in manner that will make both species and habitats more resilient to predicted changes. Habitat restoration is likely to enhance carbon sequestration and therefore will confer an added advantage in terms of Sri Lanka's national contribution to combat climate change- driven changes. Whilst making Sri Lanka more resilient to climate change these actions will also contribute indirectly to achieve national conservation targets as defined in the National Biodiversity Strategic Action Plan.

Adaptation in the Biodiversity Sector: Resilience building actions for biodiversity are presented under five NDCs (Table 5.1.5) covering management of climate- sensitive areas and restoration of degraded areas within and outside the protected areas, increased connectivity for species migration accommodate climate driven changes, possible expansion of protected areas to build the resilience of biodiversity as a system of protected areas, strengthening *ex-situ* conservation of fauna and flora and effective management of Invasive Alien Species (IAS). Some of the mitigation co-benefits of biodiversity including carbon sequestration is captured under Forestry Sector under the mitigation NDCs, where the adaptation co-benefits of forest conservation are described in NDCs below.

[36] Climate Change Risk in Sri Lanka: sector risk profiles. MoE/ADB (unpublished)

Table 5.1.5: NDCs in Biodiversity Sector

NDC #	NDCs and Actions	Target Year
NDC 1	**Management of climate- sensitive areas and restoration of degraded areas inside and outside the protected areas (PAs) network to conserve habitats that are highly vulnerable to climate change**	**2030**
	1.1 Identify habitats using existing maps that are most vulnerable to climate change-driven changes and adaptive measures taken in response to climate change to inform priority sites that need to be restored or rehabilitated both within and outside PAs	2022
	1.2 Prepare maps indicating terrestrial, wetland landscapes, coastal and marine areas such as mangroves, seagrass beds, fog-interception areas, villus etc. that should be the focus of priority actions identified above in order to enhance their resilience	2022
	1.3 Identification of species of fauna and flora that are highly vulnerable to climate change	2023
	1.4 Encourage research and studies on the most vulnerable species and habitats identified in 1.1 and 1.3	2030
	1.5 Establish long-term monitoring plots and mechanisms in climate sensitive areas to identify climate change driven changes in species and habitats	2025
	1.6 Restoration of at least 25% each of degraded terrestrial and wetland landscapes including coastal & marine habitats identified above and based on current extent and prioritized according to biodiversity value, ecosystem values and climate change vulnerability	2030
	1.7 Restore the natural ecosystem in fog interception zones at least by 25%	2030
NDC 2	**Increase connectivity in the zones that will be subjected to climate-driven changes according to current predictions through landscape approaches**	**2030**
	2.1 Conduct a feasibility assessment (based on 1.2 above) to identify connectivity corridors on a landscape level using the river basins located in the climate-sensitive areas	2023
	2.2 Restore climate-vulnerable riparian and instream areas that can act as corridors based on the above feasibility study covering at least 25% of the identified area	2027
	2.3 Monitor such corridors for their efficacy to serve as biodiversity corridors and making adaptive changes to enhance movement	2030
NDC 3	**Expansion of Protected Area (PA) extent to enhance the ability of the PA network to function as a buffer for climate change**	**2030**
	3.1 Identify ecologically/environmentally sensitive areas (based on 1.2) within the climate sensitive areas that can be annexed (included) to existing PAs	2023
	3.2 Annex (include) identified areas to existing PAs / declare as new PAs under mandated agencies	2030
NDC 4	**Strengthen ex-situ conservation programmes covering climate-vulnerable taxa and regions**	**2030**
	4.1 At least two facilities to be established for ex-situ conservation of flora in the climate vulnerable regions (botanical gardens and arboreta) within 5 years	2025
	4.2 At least two facilities to be established for ex-situ conservation of fauna in the climate vulnerable regions (ex-situ conservation centres) within 5 years	2025
	4.3 Establishing a mechanism to assist translocation/reintroduction of climate sensitive or threatened fauna and flora	2027
	4.4 Introduction of three new number of Veterinary/ Epidemiology facilities for Ex-situ Conservation Centers	2030
	4.5 Develop Gene Banks in National Museums and National Botanical Gardens and Plant Genetic Resources Center (PGRC)	2030
NDC 5	**Effective management of the spread of Invasive Alien Species (IAS) triggered by favorable climatic conditions**	**2030**
	5.1 Conduct a desk assessment based on the available distribution maps of IAS to identify IAS that are likely to undergo range expansion or whose range expansion can be facilitated by climate change and anthropogenic activities	2022
	5.2 Implement programs in critical areas as identified in 5.1 to enhance the resilience of ecological and economical systems towards possible biological invasions triggered by climate change	2030

5.1.6 Coastal and Marine Sector

Sri Lanka has 1,620 km of coastline and a vast exclusive economic zone of 517,000 sq.km. Over 80% of the total national fish catch comes from marine and coastal fishery[37] and it supports the livelihoods of many who engage directly or indirectly in fishery. The coastal region extends about 50 km inland from the coastline, which is approximately 23% of the total land area of the country, while accommodating over 25% of the population. The coastal zone is home to a major share of the industries and the country's tourist establishments[38] and contributes approximately 40% to the national GDP. Coastal beach tourism includes deep sea sport fishing, observing sea mammals, sailing, diving of varying types, boating and numerous recreational sports, sunbathing, and turtle watching in the shallower reef waters. It is estimated that coastal tourism, representing nearly 60% of total sector revenues, offers a rich gamut of value-added products[39].

Sri Lanka's national policy framework[40] highlights that the ocean resources should be utilized more effectively under the blue-green economy concept while investing in coastal conservation and pollution prevention. Coastal Zone Management Plan of 2016 sets out the framework and guiding principles for coastal zone management while the Coast Conservation Act No. 57 of 1981 and Amendments / CCD Regulations, Marine Pollution Prevention Act No. 35 of 2008 and Amendments and the Marine Environmental Protection Authority Regulations together with Fisheries and Aquatic Resources Act No 2 of the 2016 and the regulations therein provide the key legal provisions for coast conservation. Sri Lanka is now in the process of claiming an extensive, though yet to be determined additional extent of seabed area under the United Nations Convention on Law of the Sea, which will bring greater economic opportunity for the country.

Climate impacts on Coastal and Marine Sector: Impacts associated with sea-level rise and increased coastal hazards are predicted with climate change. Changes to the salinity of coastal ground water, increased flooding and damage to infrastructure are predicted with a high degree of confidence for island countries. [41] Coastal storms and surges could damage infrastructure and cause severe erosion. A detailed risk assessment for the sector[42] focused on identifying the degree of future risks and vulnerable areas and impacts on key economic activities in the coastal area. Tourism, coastal rice paddies, drinking water and lagoon fishery activities are most threatened. There could be potential migration of communities away from coastal areas as coastal erosion and salinity due to sea-level rise become more severe due to climate change.

During the El Nino in 1998, high sea surface temperatures (3-5° C above normal) wiped out coral reefs; Bar Reef marine sanctuary (95%); Hikkaduwa marine sanctuary (90%); Weligama (60%) and Rumassala (80%)[43]. Increased temperature and sea-levels will impact the inter-tidal areas with mangroves and other coastal vegetations undermining coastal resilience and protection provided by these ecosystems (against storms and tides).

Adaptation in the Coastal and Marine Sector: Coastal and marine sector adaptation priorities have been formulated under four NDCs (Table 5.1.6) covering mainly technical skills and systems development for monitoring and responding to climate change and variability. These include

[37] Fisheries Statistics 2019, Ministry of Fisheries and Aquatic Resources Development, 2019.
[38] Policy, Strategies and National Action Plan for Marine Environment Protection in Sri Lanka (Draft), Marine Environmental Protection Authority, 2018.
[39] World Bank, 2017. Sri Lanka: managing coastal natural wealth, Environment and Natural Resources Global Practice, South Asia Region Series
[40] Vistas of Prosperity and Splendour, Ministry of Finance 2019
[41] Climate Change 2014: synthesis report, Intergovernmental Panel on Climate Change, 2014.
[42] Third National Communication to UNFCCC, Climate Change Secretariat, Ministry of Environment, 2021.
[43] Status of coral reefs in Sri Lanka in the aftermath of the 1998 coral bleaching in Coral Reef Degradation in the Indian Ocean (CORDIO): Status Report 2005.Rajasuriya, A. 2005.

establishment of accurate sea level rise forecasting systems, preparation of updated vulnerability and risk maps, strengthened shoreline management measures and conserving unique areas of natural value in vulnerable coastal areas. Soft solutions for shoreline management such as mangrove restoration has mitigation co-benefits under Forestry Sector and contributing to Biodiversity Sector related adaptation benefits.

Table 5.1. 6: NDCs in Coastal and Marine Sector

NDC #	NDCs and Actions	Target Year
NDC 1	**Establish an accurate sea level rise forecasting system for Sri Lanka**	**2025**
	1.1 Establish the required database with historical tidal level data	2023
	1.2 Measure and record present Mean Sea Level (MSL) and assess and publish Sea Level Rise (SLR) measurements	2025
	1.3 Identify and establish additional sea-level measurement stations, to cover the coastline of Sri Lanka in addition to the existing stations	2023
	1.4. Estimate SLR predictions for Sri Lanka using global best practices	2025
NDC 2	**Prepare updated vulnerability and risk maps for the coastal belt of Sri Lanka**	**2026**
	2.1 Update inundation maps covering coastal area according to the sea level rise forecast	2023
	2.2 Identification of areas vulnerable to Sea Level Rise	2024
	2.3 Prepare SLR influenced risk maps for the coastal zone with 0.5m contour intervals and take appropriate actions	2025
	2.4 Use findings in 2.3 to update the existing coastal development setbacks	2026
NDC 3	**Adopt optimal shoreline management works/measures covering affected length of shoreline using a combination of hard & soft solutions to prevent coastal erosion in areas most vulnerable to SLR**	**2030**
	3.1 Start required long term data collection programmes, including wave measurements and a sediment transport study	2022
	3.2 Update the erosion management plan	2026
	3.3 Establish programs (in collaboration with universities and other research agencies) for monitoring of coastal erosion and collect related data/information on: coastal erosion trends and status, scientific investigations of sediment balances and assessments of sediment sources, threats to dwellings, land use and critical habitats from erosion, bathymetric & hydrologic conditions	2030
	3.4 Restoration of coastal ecosystems including mangroves covering 1,000ha. (this action is linked to action 1.6 of the Biodiversity Sector NDC 1)	2030
NDC 4	**Identify and declare coastal and marine natural areas of high priority for building resilience for climate change impacts**	**2027**
	4.1 Prepare appropriate criteria and list of candidate sites to be declared as high priority natural areas	2025
	4.2 Declare and manage high priority natural areas as required through gazette notifications	2027

5.1.7 Health Sector

Sri Lanka has a pluralistic healthcare system that combines allopathic/western medicine, with traditional forms of treatment such as Ayurveda, Siddha, Unani and Homeopathy. However, the majority of investments and improvements have led to the expansion of the allopathic system and access to free healthcare for all citizens. The national health system is well advanced due to advanced social policies in the post-independence era and consists of 603 public hospitals (3.6 beds for every 1,000 persons) with one qualified doctor for every 1,203 persons/one nurse for every 570 persons in 2019. Further, there are 105 government Ayurvedic hospitals with 4,485 beds and 1,759 qualified Ayurvedic doctors[44]. Sri Lanka performed well in its efforts to attain the health-related Millennium Development Goals (MDGs), and the targets set for 2015 for child mortality, maternal mortality, reproductive health, and eradication of malaria were successfully met with a well-established healthcare system. Infant mortality is 7 per 100 live births, maternal mortality is 35 per 100,000 live births. However, malnutrition among children and women is inexplicably high in Sri Lanka and vector-borne diseases like dengue and leptospirosis claim many lives annually. Major concerns include pregnant women with low BMI on or before 12 weeks of pregnancy (15%), low birth weight of newborns (nearly 12%), underweight infants (6.4%), young children aged 1-2 (12%), aged 2-5 (19%) can be highlighted[45]. Addressing these areas of concern in the health sector will be challenging as food security becomes vulnerable to climate change.

The national policy framework identifies the healthiness of the population to be of paramount importance. It expands indicating that health care will be provided free for all citizens as per the national health policy. Ministry of Health operates with guidance from the National Health Policy 2016-2025 and the National Health Sector Master Plan 2016-2025.

Climate change impacts on the Health Sector: Any increase in global average temperature is projected to affect human health with negative consequences. Heat-related morbidity and mortality, ozone depletion related mortality and risks for vector-borne diseases increasing in numbers and range are all predicted with a high level of confidence. Undernutrition and risks of water-and-vector borne diseases will substantially increase with global average temperature rise by 2°C[46]. In Sri Lanka, major risk factors relating to climate change are; high temperature related heat stress, temperature and humidity-related vector population increase, migration of vector-borne disease range to higher altitudes and other areas (dengue/filaria) or resurgence of presently controlled vector-borne diseases (malaria), water-borne diseases such as chronic kidney disease, typhoid, climate induced disaster frequency and intensity increase related health risks such as floods/droughts/poor water quality. Climate change could exacerbate existing nutrition-related issues, poor nutrition due to persistent disaster exposure and chronic undernutrition from food insecurity. Air pollutants, higher temperatures and humidity increase could worsen respiratory diseases.

Adaptation in the Health Sector: Health sector adaptation targets are presented under six NDCs (Table 5.1.7) covering policy level initiatives to mainstream targeted climate resilience actions, improved capacity to manage climate influenced health and disease conditions, addressing air pollution related health impacts and reduce morbidity and mortality from climate induced disasters.

[44] Annual Report 2019, Central Bank of Sri Lanka, 2019.
[45] Family Health Bureau, Ministry of Health and Nutrition website, https://fhb.health.gov.lk/index.php/en/statistics
[46] IPCC website, https://www.ipcc.ch/reports/

Table 5.1.7: NDCs in Health Sector

NDC #	NDCs and Actions	Target Year
NDC 1	**Policy initiatives for enhancing the climate resilience of the health sector promoted and integrated to all related sectors**	**2030**
	1.1 Development and implementation of the Heat – Health Action Plan (HHAP) for Sri Lanka	2030
	1.2 Development and implementation of the National Strategic Plan for Health, Environment and Climate Change (NHSPEC)	2030
	1.3 Development and implementation guidelines and standards to make Green and Healthy Hospitals	2030
	1.4 Health action plan prepared to reduce the disease burden due to air pollution and implementation commenced	2030
NDC 2	**Improved capacity to manage non-communicable diseases (NCD) and health conditions directly attributable to climate change**	**2024**
	2.1 Identify diseases and health conditions expected to aggravate due to climate change	2021
	2.2 Develop management guidelines for the prioritized diseases and health conditions including clinical and preventive guidelines	2024
	2.3 Capacity building of public health system in addressing climate change influenced diseases and health conditions	2024
	2.4 Identify potential at-risk categories/vulnerable groups (elderly, children, vulnerable worker groups, and other vulnerable categories) and to develop a road map in managing climate change-induced NCDs	2024
	2.5 Strengthen research capacity on generating evidence on climate change and health impacts	2022
NDC 3	**Manage the worsening of under-nutrition and malnutrition due to climate change**	**2023**
	3.1 Develop a mechanism to receive and analyze food availability related early warning to minimize nutrition- associated health issues	2023
	3.2 Social welfare systems strengthened to cover vulnerable groups including families below the poverty line, elderly, disabled people, nursing mothers and young children in Medical Officer of Health (MOH) areas identified as vulnerable to food insecurity	2022
	3.3. Strengthen the public health system to identify and intervene early in nutrition-related issues	2023
NDC 4	**Strengthen surveillance and management of climate-sensitive vector and rodent borne diseases (dengue, malaria, filaria, leishmaniasis and leptospirosis)**	**2024**
	4.1 Strengthen vector borne disease surveillance system for the above diseases	2022
	4.2 Develop early warning systems at MOH level based on rainfall/temperature forecast for each climate sensitive vector borne disease	2023
	4.3 Capacity building of the public health system, local authorities and other stakeholders in prevention of occurrence of outbreaks and to rapidly respond to early warnings through effective interventions in prevention and control infectious diseases	2024
	4.4 Strengthen public health risk communication regarding vector borne disease control during predicted outbreaks	2024
	4.5 Inter-sectoral coordination and information system linked to the surveillance system for coordination with public health, local authorities, and other stakeholders	2024
NDC 5	**Reduce morbidity and mortality from extreme weather/climate events (floods, droughts, landslides and other climate-related emergencies)**	**2023**
	5.1 Strengthening timely and accurate early warning receipt and dissemination to health sector on possible extreme events or rainfall variability and linking them to national, regional, MOH and village level interventions	2022
	5.2 Risk assessment for all hazards including climate-related events for the health sector	2022
	5.3 Improved health preparedness for all hazards including climate related events at national, subnational, MOH and village level both in curative and preventive sectors	2023

	5.4. Public awareness on health impacts of climate change and promotion of resilience designed and disseminated through traditional, electronic and social media on how to address immediate disaster risks	2023

5.1.8 Urban Planning and Human Settlement Sector

Sri Lanka's urban population is 18.7% and expected to reach 21% in 2030[47]. The above statistics are based on the existing definition of 'urban' counting populations living in defined Municipal Councils (MCs) and Urban Councils (UCs). It is believed that the actual urban population is higher. Urban sprawl is increasingly evident throughout the country giving rise to many issues including increased demand for services, increased congestion and disaster-related impacts, health risks, inappropriate housing, urban heat island effect and low-living standards of urban poor.

The government, in its new policy framework,[48] emphasise rural development and providing services and infrastructure facilities equally across the urban and rural sectors. The concept of *agro industrialization* has been proposed to de-urbanize burgeoning cities and the government has launched many projects to bridge the infrastructure and service divide. Ministry of Urban Development and Housing sets the policies for urban development. National Physical Planning Policy (2019) and the National Physical Plan 2017–2030 provides the overall framework and guidelines for spatial planning. Urban Development Authority Act (Amended) No. 36 of 2007 and respective Urban Development Authority Planning and Building Regulations provides the mandate for the Urban Development Authority (UDA) to undertake urban planning and land allocation.

Climate change in the Urban sector: Outmigration in agriculture-dependent communities as climatic threats worsen is expected to overpopulate cities across the world. This could lead to the expansion of unplanned, low-income settlements in urban centres that face a multitude of vulnerabilities.[49]

Human settlements have two distinct and obvious threats from climate change. Higher temperatures will create inhospitable conditions in both urban/suburban areas across the country. Urban heat islands will amplify the impact of heatwaves in cities. Day and night-time temperatures increase will have an impact on energy consumption for cooling. In the Dry Zone, higher temperatures, high evaporation rates and longer dry spells will cause water shortages. Drought related water shortages are already evident in cities located in the higher watersheds -such as Nuwara Eliya and Badulla. Large and expanding urban areas in the Wet Zone may also face similar challenges as demand grows with urban expansion.

The second climate-related risk to human settlements is the increased frequency of weather-related disasters, increased risk of flood, drought and landslides.[50] Positive rainfall anomalies for the Wet Zone indicate that towns already at flood risk in the south-western quarter of the country will have heightened risks. Plantation worker housing in the hill country is particularly susceptible to landslides, and their vulnerability is higher due to poor housing conditions and economic status. Sri Lanka's coastal zone is densely populated, especially in the western/southern areas. Amongst other climate change-related issues in coastal areas, drinking water schemes are highly vulnerable to sea-level rise and salinity intrusion.

Adaptation in the Urban Planning and Human Settlement Sector: Adaptation measures are organized under four NDCs (Table 5.1.8). They reflect the need for improved planning, integrating disaster risk reduction and future climate threats, enhancing climate resilience in the built environment and minimizing impacts of slow-onset climate change events. Some of these adaptation measures (urban

[47] UN HABITAT, 2020. World Cities Report 2020: The Value of Sustainable Urbanization
[48] Vistas of Prosperity and Splendour, Ministry of Finance 2019
[49] IPCC website, https://www.ipcc.ch/reports/
[50] Ministry of Environment, Third National Communication of Sri Lanka, 2021

forestry, environmentally friendly transportation and green buildings) will have certain climate mitigation benefits which are not accounted for in the targets set in Chapter 4.

Table 5.1.8: NDCs in Urban Planning and Human Settlement Sector

NDC #	NDCs and Actions	Target Year
NDC 1	**Enhance the resilience of human settlements and infrastructure through mainstreaming climate change adaptation into national, sub-national and local level physical planning**	**2025**
	1.1 Integrate most current climate change risk and vulnerability into physical planning at all levels	2022
	1.2 Prepare the sub-national and local plans considering climate risks and vulnerability and the recommendations of the National Physical Plan (NPP)	2025
	1.3 Adhere to the guidelines prescribed by the NPP and UDA in all urban infrastructure projects and programmes	2022
	1.4 Introduce adaptation measures such as urban zoning incorporating disaster risk, forest parks, ground water recharge, air passages/wind corridors, wise use of wetlands and roadside planting into urban planning to build resilience to climate change	2023
	1.5 Integrate and adhere to the Guideline for Climate Resilient Human Settlement and Infrastructure developed by the Climate Change Secretariat	2022
NDC 2	**Incorporate Disaster Risk Reduction (DRR) into the urban and human settlement planning/implementation in areas of high vulnerability to climate change risks**	**2025**
	2.1 Develop Guidelines on Climate Change influenced Disaster Risk Management (DRM) for urban and human settlement planning	2022
	2.2 Design and maintain infrastructure giving due consideration to the runoff system/drainage and flooding	2024
	2.3. Incorporate slope stability and soil conservation measures in developing infrastructure in hilly areas	2023
	2.4. Assess landslide / flood risk to human settlement and infrastructure and introduce measures to reduce the vulnerability in high- risk areas	2025
	2.5. Assess drought risk to human settlement and introduce measures to reduce vulnerability in high-risk areas	2025
NDC 3	**Establish a climate-resilient built environment**	**2030**
	3.1 Integrate climate risk projections into climate-resilient built environment strategies implemented by respective stakeholder institutions	2022
	3.2 Review and update climate-resilient design strategies to address emerging climate risks	2022
	3.3Amend and gazette existing human settlement plans to integrate climate-resilient strategies 3.2	2023
	3.4 Review, update and enforce existing rules and regulations to prevent built environments in areas highly vulnerable to climate change	2025
	3.5 Include sustainable built environment concepts into Architecture and Engineering curriculars	2024
	3.6 Promote vertical housing solutions, where appropriate to communities living in high climate risk areas	2030
NDC 4	**Minimize the impact of slow onset events (sea-level rise) on coastal settlements and infrastructure**	**2030**
	4.1 Design coastal settlements and associated infrastructure considering future sea-level rise	2025
	4.2 Demarcate protection areas from sea level rise to facilitate for shifting urban densification inward	2030
	4.3 Prepare and commence implementation of risk management plans for existing coastal infrastructure and settlements	2025

5.1.9 Tourism and Recreation Sector

The tourism sector was the third-largest foreign exchange earner in 2019 for Sri Lanka. The sector's contribution and foreign exchange earnings have nearly doubled in four years from US$ 2.4 billion in 2014 to US$ 4.3 billion in 2018. The number of tourists also grew over this period from 1.5 million to 2.3 million. Sri Lanka Tourism Development Authority estimated that the sector employs 250,000 people directly and up to 2 million, indirectly.[51] Tourism in Sri Lanka has had several major setbacks including the Easter Sunday terrorist attacks in 2019 and the Covid-19 pandemic in 2020-2021. Investment in tourism-related enterprises/infrastructure and the government's vision to grow tourism into its top foreign exchange earner will support the industry to recover from the current crisis. However, post-Covid tourism development will need to give due recognition to climate risks such as rising temperatures, sea-level rise and increasing natural disasters.

Tourism has been identified as one of the most important service sectors for earning foreign exchange in the current development policy framework, which sets a very ambitious target of USD 10 billion annual earnings from the sector by 2025. Further, it highlights the potential for catering to the growing health tourism sub-sector and community-based tourism. The strategic positioning of Sri Lanka in the international tourism market is provided by the Tourism Strategic Plan 2017-2020 (currently being updated), and the new tourism policy which is under development. Sri Lanka's next five-year tourism strategic plan and policy framework will incorporate the guiding principles spelt out in the Roadmap for Covid-19 recovery *Putting People First: Building a More Resilient Tourism Sector in Sri Lanka* and the Tourism Strategic Action Plan (2020-2022) developed by Sri Lanka Tourism Development Authority for post-Covid tourism.

Climate risks to the Tourism Sector: Global warming has already affected tourism, with anticipated increased risks projected even under 1.5°C of warming, and impacting seasonal tourism depending on sun and beach. Risks for tourism activities in tropical and sub-tropical regions will increase due to heat extremes, storms, loss of beaches and degradation of coral reef resources.[52]

The majority of tourist destinations in Sri Lanka (approximately 60%) are in coastal areas where elevation is less than 2m from the sea-level. In addition, climate change impacts on the natural resources that tourism depends upon, such as inland water bodies, rivers, mountains, forests, marine biodiversity including coral reefs, are significant and already visible. Long droughts will impact visitation in wildlife parks and forest reserves. Meanwhile, due to warmer temperatures and heat stress, the sector vulnerability could be further increased. Furthermore, meeting water requirements for tourism establishments in drier destinations (north, north-west and east) will become increasingly challenging. Tourism establishments could face higher insurance costs against frequent disasters such as floods (Kalutara, Ratnapura, Kegalle, Batticaloa and Ampara districts) and landslides (Nuwara Eliya, Ratnapura, Kandy, Matale, Badulla districts). Therefore, the NDCs for the sector address building resilience of the sector to anticipated changes.

Adaptation in the Tourism Sector: Tourism sector adaptation targets are presented under three NDCs (Table 5.1.9) covering sustainable tourism practices, sector risk reduction and resilience building measures incorporating the green building concept. The NDCs for the tourism sector includes energy efficiency and green building, landscaping-related activities which will provide mitigation co-benefits but are not accounted for in the mitigation actions described in Chapter 4.

[51]Annual Statistical Report, 2019, Sri Lanka Tourism Development Authority, 2019.
[52] IPCC website, https://www.ipcc.ch/reports/

Table 5.1.9: NDCs in Tourism Sector

NDC #	NDCs and Actions	Target Year
NDC 1	**Build resilience through sustainable tourism practices and improved risk preparedness in destinations of high climate change vulnerability**	**2025**
	1.1 Undertake studies to assess climate impacts on tourism, carrying capacity studies and identification of tourism facilities in areas that are vulnerable to climate change	2022
	1.2 Identification and promotion of adaptation measures in the above areas	
	1.3 Advocate diversified tourist attractions and products (e.g: Cultural, Adventure, Lifestyle, Festivals and Marine Tourism etc.) as alternatives to identified vulnerable destinations	2025
	1.4 Inclusion of guidelines/principles for sustainable tourism practices relevant to different stakeholders	2025
	1.5 Increased number of tourism establishments and destinations certified under the National Sustainable Tourism Certification Scheme by Sri Lanka Tourism Development Authority (SLTDA) in collaboration with Global Sustainable Tourism Council (GSTC)	2025
NDC 2	**Introduce risk reduction and risk transfer mechanisms for climate-induced disasters affecting tourism**	**2025**
	2.1 Strengthen early warning systems and capacity building in most vulnerable tourism destinations	2024
	2.2 Implement coastal rehabilitation and protection measures together with Coast Conservation Department (CCD) and Marine Environment Protection Authority (MEPA) in critical areas	2025
	2.3 Expand development of coastal tourism zonal planning with CCD, Urban Development Authority (UDA) and SLTDA covering all vulnerable coastal areas	2025
	2.4 Develop climate inclusive insurance scheme for risk management in tourism	2025
NDC 3	**Promote climate resilience in the tourism sector by introducing green building design to all new constructions and refurbishments**	**2024**
	3.1 Review and update existing Green Building Guidelines (GBG) specific to tourism to include climate change and ecological aspects	2022
	3.2 Legalize GBG specific to tourism	2023
	3.3 just Enforce the above guidelines for all new constructions and refurbishments in the tourism sector	2024
	3.4 Initiate programmes for the Architects and Engineers responsible for designing tourism-related structures through their respective professional associations on the Green Building Codes on tourism	2022
	3.5 Dissemination of Green Building Code on tourism with planning committees of the relevant local authorities	2023

Chapter 6: Loss and Damage NDCs

Climate-related hazards pose a significant threat to Sri Lanka's economic and social development. The Global Climate Risk Index Report ranks Sri Lanka second among the countries most affected by extreme weather events in 2017, and one of ten countries most affected in 2018. There were several large-scale disaster events in recent years such as severe droughts in 2011 and 2016, and major floods and landslides in 2011, 2014, 2016, and 2017. Extended drought and floods in 2016 and 2017 disrupted two rice cultivation cycles and affected over 2 million people according to government estimates, curtailing economic growth and causing food inflation[53]. The estimated damages and losses from the floods and landslides in May 2016 were over USD 473 million and in May 2017 it was estimated at USD 368 million[54]. Reconstruction needs respectively were estimated at US$ 960 million and US$ 790 million. In 2017, the contingent liability of the government was LKR 23.8 billion (US$ 149 million) or approximately 1% of total government expenditure[55]. Historical data show an increasing trend in the frequency and severity of floods. Further, Sri Lanka needs to confront slow-onset climate hazards such as sea-level rise, salinization, desertification etc. which could lead to severe consequences such as lack of potable water, loss of agriculture and food production, loss of biodiversity and habitats.

World Bank study on South Asia's Hotspots[56] estimated that 87% of Sri Lanka's population lives in moderate or severe hotspots. It is reported that, there were 64 extreme weather events over the period from 2000 to 2015. By 2050, potential impacts due to climate change are foreseen to be approximately a 1.2 % loss of annual GDP. It is estimated that the government could be facing US$380 million losses each year from climate-related disasters. If infrequent disasters such as cyclones or severe floods occur, this will be much larger. Further, it is estimated that Sri Lanka could face housing/roads/ losses and relief needs related to natural disasters of more than SL Rs 237 billion (US$ 1.8 billion) once every 100 years. This is equivalent to 2.4% of GDP and 14.2% of total government expenditures, taken as the total 2013 estimated expenditure figure[57]. These estimates do not include long term losses related to economic displacement, effects on levels of poverty, social security, implications on health, education, gender and other social issues. Further, eroding of natural assets, watersheds, cultural monuments, tourism hotspots/ beaches etc., have not been accounted for in these calculations.

Loss and Damage revisions in 2020

The Nationally Determined Contributions (NDC) revision process is an opportunity to draw attention to the national relevance of averting, minimizing, and addressing disaster losses and damages. These revisions are built around recent work on understanding disaster losses and damages that include:

- Disaster Information Management System - DesInventar Database (http://www.desinventar.lk) contains historical information on losses from natural and man-made disasters in Sri Lanka since 1974. Work is in progress to develop an online sector-wise loss and damage (L&D) reporting system by the Disaster Management Centre supported by the World Bank.

- Ongoing projects such as the Climate Resilience Multiphase Programmatic Approach supported by the World Bank. The project components include forecasting and early warning of high impact

[53] International Monetary Fund, Sri Lanka: Third Review Under the Extended Fund Facility and Request for Modification of Performance Criterion. Washington, DC.2018 quoted in: Asian Development Bank, The Enabling Environment for Disaster Risk Financing in Sri Lanka, ADB Country Diagnostics Assessment February 2019
[54] Ministry of National Policies and Economic Affairs, Ministry of Disaster Management, Post Disaster Recovery Plan Sri Lanka floods and Landslides, 2017
[55] World Bank, Contingent Liabilities from Natural Disasters Sri Lanka, 2018
[56] World Bank, *South Asia's Hotspots: The Impact of Temperature and Precipitation Changes on Living Standards.* South Asia Development Matters (2018)
[57] Word Bank, *Fiscal disaster risk assessment and risk financing options* (2016) http://documents.worldbank.org/curated/en/430141467229470955/Fiscal-disaster-risk-assessment-and-risk-financing-options

weather, floods, and landslides; upgrading and expanding the hydrological and meteorological observation networks to ensure that these networks are well functioning and interoperable.

- *'Improving Meteorological Observation, Weather Forecasting & Dissemination Project'* supported by JICA was initiated in 2014 to provide equipment and training to the Department of Meteorology aiming at the build-up of reliable observation and forecast techniques for extreme weather phenomena (heavy rain, strong wind, thunder, etc.) and proper dissemination of information on weather in a user-friendly manner.
- Post Disaster Needs Assessments conducted following floods and landslides in 2016 and 2017 assessed the damages and losses that occurred in the social, productive, infrastructure sectors and the implications related to cross-cutting issues. Further, key development sector professionals have been trained by the UNDP in 2017 on conducting damage and loss assessment as part of the Post Disaster Needs Assessment (PDNA) methodology.

The recommended approach for managing climate-related L&D is to take a comprehensive approach similar to the framework for managing climate and disaster risk (Figure 6.1) that builds on the current technical investments and operational framework for disaster risk management. Understanding the full spectrum of risk, and future damage and losses due to climate change require a broader process and greater data availability. However, Sri Lanka will base its current NDCs (2021-2030) on institutional and coordination mechanisms that operationalizes the Sendai Framework for Disaster Risk Reduction (2015-2030) and the Warsaw International Mechanism. This includes a comprehensive understanding of risks associated with hydro-meteorological disasters aggravated by climate change, natural processes impacted by climate change contributing to new hazards and disasters, a strong data collection and reporting system, capacities for forecasting and early warning, risk mitigation and risk transfer mechanisms to inform and enable risk-informed national and local development planning and investments. The updated loss and damage NDCs are presented in Table 6.1.

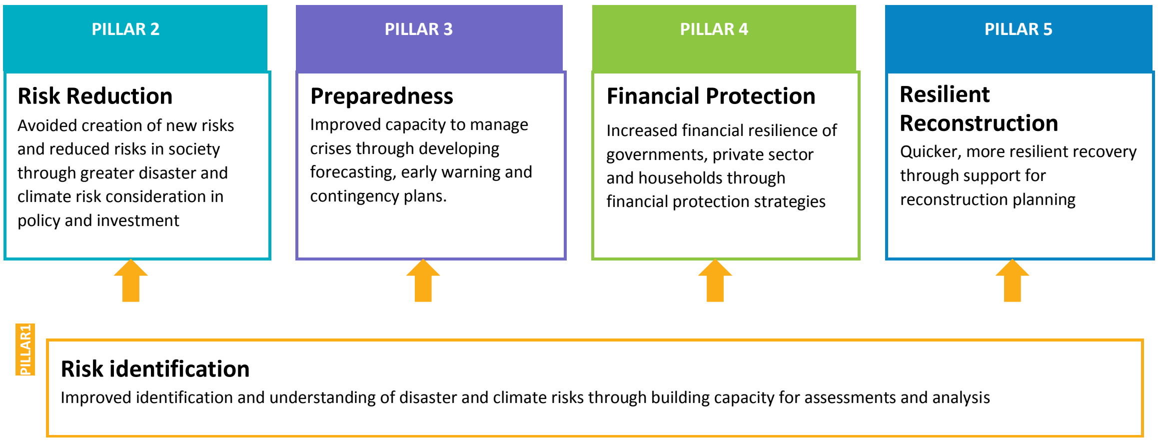


Figure 6.1: An operational framework for managing climate and disaster risk (World Bank, 2013)[58]

[58] World Bank, Building Resilience: Integrating climate and disaster risk into development. Lessons from World Bank Group experience, 2013

Table 6.1:NDCs in Loss & Damage Sector

NDC #	NDCs and Actions	Timeline
NDC 1	**Conduct a gap analysis to assess the current status and understanding of L&D:** This includes weather and climate-related extreme events, slow-onset disasters and natural processes attributed to climate change. The analysis would cover; i) awareness and capacity on L&D; ii) data collection and analysis; iii) policy, institutional arrangements and mandates.	2021-2023
NDC 2	**Strengthen the existing weather and climate forecasting system:** i) to improve early warning and user services; ii) to improve capabilities to predict and record damages and losses for weather and climate-related extreme events, slow-onset disasters and natural processes attributed to climate change; iii) to determine losses and damages attributable to climate change.	2021-2025
NDC 3	**Improve data management systems to record losses and damages per sector**: This involves taking 2015 as the base year, to assess and quantify both economic and non-economic losses and to inform disaster and climate risk management strategies and incorporate into national development planning process	2021-2025
NDC 4	**Establish an overarching, nationally appropriate, functional institutional mechanism for L&D** in line with the 'Warsaw International Mechanism for Loss and Damage' (based on the Gap analysis – NDC 1). This institutional mechanism will have the mandate to coordinate with multiple sector entities, in addition to monitoring functions, it will have financial and budgetary authority	2021-2030
NDC 5	**Develop a Comprehensive Risk Management Framework** founded on the provisions of the 2005 Disaster Management Act but expanded to include the entire spectrum of climate-related extreme events, slow-onset disasters and natural processes attributed to climate change and anticipated future losses and damage. This will support mainstreaming of disaster management strategies/ adaptation plans implemented nationally and locally by all relevant sectoral agencies i) as a basis to minimize L&D; ii) to enable and ensure development investments are risk-sensitive and to recover residual L&D by incorporating appropriate mechanisms for risk transfer (Social protection, Risk retention, economic options such as insurance, contingency/emergency funds).	2021-2030

Chapter 7: Integrating Sustainable Development Goals and Gender to the NDCs

The NDC revision process provided an opportunity to closely examine the alignment of proposed climate actions with Sustainable Development Goals (SDGs) and their targets, and to analyze the gender dimensions of mitigation and adaptation priorities.

The Paris Agreement calls for gender equality and women's empowerment and urge member states to adopt gender-responsive approaches. The UNFCCC's Gender Action Plan recommends gender mainstreaming in all climate change processes. Sri Lanka's NDC review process, therefore, presented an opportunity to analyse gender disparities from a national development context, to narrow down existing disparities and identify ways to realize the optimum potential of men and women through climate action. The NDCs also provide a means to benefit from the knowledge and capabilities, specifically of Sri Lanka's educated and literate female population, when implementing mitigation and adaptation measures. Further, gender-responsive planning and implementation of NDCs ensure that climate actions do not contribute to creating or widening gender disparities, and that they contribute to achieving the national gender equality goals and commitments.

The government of Sri Lanka has advanced its policy commitments to gender equality and women's empowerment. The National Development Policy Framework *Vistas of Prosperity and Splendor* aspires women to be economically and socially empowered and specifies strategies that recognize and enable women's contribution to the economy and society. The NDCs provide a vehicle to support these national policy commitments on gender equality. Analysis conducted during the NDC revision process, proposes a multi-step approach to integrate gender into 10-year NDC implementation plans by sector. This includes sector-specific gender analysis where needed, developing gender-responsive actions, improving capacities to engage women in planning and monitoring of NDCs and allocating budgets/resources for gender-responsive actions (Figure.7.1).

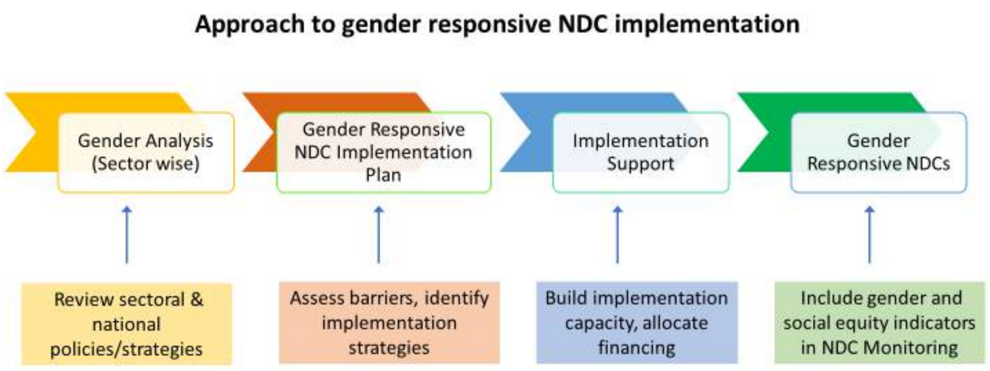


Figure 7. 1: Approach to gender responsive implementation

NDC-SDG Interlinkages

Sri Lanka achieved many of the Millennium Development Goals (MDGs) ahead of time. The country was signatory to the new global development agenda in 2015 committing to achieve the Sustainable Development Goals and targets therein by 2030.

> Sri Lanka has instituted a number of mechanisms to support the coordination and achievement of the Sustainable Development Goals (Agenda 2030) presented at the United Nations General Assembly 2015. In 2017, the Parliament passed the SUSTAINABLE DEVELOPMENT ACT, No. 19 OF 2017 which established a High-Level Sustainable Development Council headed by the Secretary to the Executive President and constitutes membership from academia, civil society and provincial councils. The National Policy and Strategy for Sustainable Development is available in draft form and the Department of Census and Statistics has measured Sri Lanka's progress against SDG indicators with available data in 2018[59]. Sri Lanka presented a voluntary national review to the High-Level Policy Forum on SDGs in 2018. The National Policy and Strategy for Sustainable Development adopts several policy targets around climate change that include, building greater resilience to climate-induced hazards and integrating climate change into national strategies, plans and programmes. Accessing climate finance, increased awareness and focusing on vulnerable groups such as women, children etc., are also mentioned as policy priorities.

In 2018, a study of which factors would accelerate the pace of SDG achievement in Sri Lanka, found climate change integration into development planning to be among the top ten such 'accelerators'.[60] It transpired through this study that integrating climate change measures into national policies, strategies and planning (SDG target 13.2) and ensuring sustainable food production systems and implement resilient agricultural practices (SDG Target 2.4) were among the ten most important development accelerators for Sri Lanka.

During the NDC revision process alignment of the proposed climate actions with the SDG framework of 17 goals and 169 targets was reviewed. A more detailed review was undertaken for mitigation targets proposed in these NDCs to determine if these actions negatively impact SDG achievement. The analysis used the SDG Climate Action Nexus tool (SCAN-tool).[61] The analysis found over 270 interlinkages with the majority being positive interactions complementing the SDG targets. Strong positive interlinkages were observed on SDG 7 (affordable and clean energy), SDG 8 (decent work and economic growth), SDG 9 (industry, innovation and infrastructure) and SDG 11 (sustainable cities and communities) whereas some trade-offs or mixed interactions were observed on SDG 1 (no poverty), and SDG 15 (life on land). Agriculture sector NDC actions have numerous synergies and interlinkages to most SDGs except for SDG 1 and SDG 15. Transport sector actions indicate a few trade-offs for SDG 6, 14 and 15. Nevertheless, the sector has a large number of complementing activities to SGDs. Even though a significant contribution of the power (electricity) sector's NDC actions can be expected for many SDGs, some trade-offs on SDG 1,2 3, 6 and 14 are observed, indicating that renewable energy proliferation may have impacts on agriculture and water. It is important to understand negative co-relations and institute necessary safeguard mechanisms during implementation. Industry, forestry, and waste NDC actions are mostly synergistic with SDGs.

---

[59] Department of Census and Statistics 2018

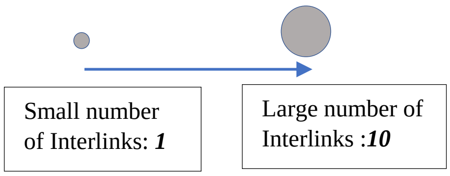
[60] Understanding SDG interactions in Sri Lanka: initial results from network analysis. Stockholm Environmental Institute and UNDP 2019 (unpublished)

[61] https://ambitiontoaction.net/scan_tool/

Figure 7.2: Summarized interactions between main sectors and their mitigation actions and SDGs

Colour chart depicting colour codes for the different level of NDC-SDG interlinks

Colour	**Interlink**
100%	Strong interlinks, and all positive aspects complementary to SDGs
75-99%	Strong interlinks and synergies and active contributions to SGDs though a few trade-offs
50-75%	Moderate contribution to SDGs/SDG targets
25-49%	Trade-off outweigh synergies, and has some negative impacts
0-24%	Mostly negative or trade-offs, and may have a negative impact on SDG targets
	No Interlink



In this document, development co-benefits of adaptation NDCs are descriptively tagged with corresponding SDG targets (see table 7.1 below) to demonstrate direct positive correlations and possible trade-offs. In general, all adaptation NDCs respond to targets on understanding vulnerability and improving resilience under Goal 13 on climate action. Another SDG target that positively correlates to a number of NDC actions is Target 1.5 on reducing death and damages from extreme weather events and promoting the resilience of vulnerable people. Sectoral adaptation measures, generally, align with targets under sector-specific SDGs. This is strongly observed in NDCs for Agriculture, Health, Biodiversity, Coastal, Fishes, Urban Settlements and Water. There are areas, where SDG achievement may exacerbate climate vulnerability or impact climate action. SDGs emphasize continued economic growth and development prioritizing food security, incomes, water and sanitation facilities, housing, energy and industrial growth. Achieving these development goals could well compromise long term resilience, especially of fragile eco-systems (coastal, forests and watersheds) and expose more communities to climate hazards in the future. The country's National Sustainable Development Policy, therefore, underscores the need for climate-resilient and risk-incorporated development investments.

Table 7.1: Linkages between SDGs and adaptation NDCs

NDC Sector	Corresponding SDGs (+)
All adaptation NDCs	13 CLIMATE ACTION: 13.1/13.2/ 13.3 & 13b
Agriculture	1 NO POVERTY: 1.5; 2 ZERO HUNGER: 2.4/2.5; 6 CLEAN WATER AND SANITATION: 6.4/6.5
Biodiversity	14 LIFE BELOW WATER: 14.2/ 14.5; 15 LIFE ON LAND: 15.1/15.2/15.3/15.4/15.5 and 15.8
Coastal	14 LIFE BELOW WATER: 14.2/14b; 11 SUSTAINABLE CITIES AND COMMUNITIES: 11.9
Fisheries	14 LIFE BELOW WATER: 14.2/14.4/ 14.5
Health	3 GOOD HEALTH AND WELL-BEING: 3.3/ 3.4/3.9 and 3d; 2 ZERO HUNGER: 2.2
Livestock	2 ZERO HUNGER: 2.4 and 2a
Water & Irrigation	6 CLEAN WATER AND SANITATION: 6.1/6.3/6.4/6.5/ 6.6 & 6a/ 6b
Urban	11 SUSTAINABLE CITIES AND COMMUNITIES: 11.3/11.5/11.6/11.9/11.10
Tourism	8 DECENT WORK AND ECONOMIC GROWTH: 8.9; 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE: 9.4

Chapter 8: Means of Implementation

To fully implement the climate actions contained in these NDCs, Sri Lanka will require finance, technology transfer and capacity building in line with Article 4 of the UNFCCC and Articles 9, 10 and 11 of the Paris Agreement. These articles are explicit on supporting developing countries to implement climate change actions and increasing mitigation ambition, considering *'the common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances'*. Paragraph 5 of Article 4 of the Paris Agreement specifically states that *"support shall be provided to developing country Parties for the implementation of this Article, in accordance with Articles 9, 10 and 11, recognizing that enhanced support for developing country Parties will allow for higher ambition in their actions*."

While Sri Lanka presents increased mitigation ambition in this Nationally Determined Contribution, and seeks international support to realise this ambition, the country more urgently requires support for adaptation and reducing losses and damages from climate-induced disasters. This includes adaptation in agriculture, food production, water for drinking and irrigation, health and human settlements, biodiversity, and coastal protection. Improved climate forecasting, climate risk communication and early warning and comprehensive risk management framework is especially important for a country facing multiple climate hazards.

Finance: Finance is a crucial factor in achieving the more ambitious targets. The Sri Lankan government commits public finances to support certain climate actions which are aligned with national development priorities. However, to increase ambition beyond this, the country requires external financial assistance. As a developing country that is highly vulnerable to adverse effects of climate change, enhanced finance for adaptation and low-carbon development are prerequisites to achieving the targets set out in this document. As part of the NDC revision process, extensive analysis and consultations are being undertaken to produce cost estimates for conditional and unconditional mitigation measures through 2021 and 2030.

To meet its conditional contribution, Sri Lanka needs to mobilize substantial climate finance from mechanisms set up by the UNFCCC, the Paris Agreement and leverage bi-lateral agreements for low-carbon development. Sri Lanka's National Adaptation Plan (NAP) will be updated with the Green Climate Fund (GCF) supported NAP Readiness Project which will develop a long-term pipeline of adaptation priorities for technical and financial assistance.

Technology: Sri Lanka requires access to innovative adaptation technologies to build resilience; and requires mitigation-related technology transfer to enable the country to leapfrog the fossil fuel dependent technologies and steer the country towards a low-carbon economy. The NDCs can be attained with the right mix of access, affordability and scale/mix of technologies pertaining to climate smart agriculture, modern crop management methods, climate forecasting and early warning, water and irrigation conveyance, climate-smart cities and tourism infrastructure, energy generation (new renewable energy technologies) and energy storage facilities, low carbon transport and urban infrastructure, coastal resilience improvement and cutting edge agro-technology. NDC implementation and monitoring plans will outline the technology availability and needs for each NDC. Enabling the transfer of appropriate, cost-effective, and modern technology is vital to achieving low carbon development and resilience building in vulnerable countries such as Sri Lanka.

Capacity Building: It is critical that the Paris Agreement's capacity-building provisions are implemented successfully to enable developing countries to better implement and monitor NDCs.

Additional technology transfer and capacity building are required to fully implement Sri Lanka's mitigation and adaptation contributions. Some specific national needs include:

Generic capacity-building needs to deliver the NDCs include:

- Institutional development and strengthening, especially for overall coordination, monitoring and reporting;
- Developing human resources through education, training, and research;
- Networking, partnerships, and sharing of experiences across sectors and beyond;
- Web-based tools/ICT applications/online courses to improve technical understanding and new knowledge.

Table 8.1: Some urgent capacity needs to implement mitigation & adaptation actions

Capacity needs for mitigation actions	Capacity needs for adaptation actions
Industry knowledge and applications on off-shore wind resource development, SMART grid, energy storage including pumped hydro technology, tri-generation, modern transport sector infrastructure developments such as LRT, BRT systems, circular economy practices, eco-industry park concepts, Design for Sustainability (D4S), Life Cycle Approach (LCA), circular economy, and digital economy, precision agriculture and mechanization, value addition and modern recycling technologies, advance composting and waste thermal treatment (e.g pyrolysis technology for energy recovery), Land-fill Gas technology, and centralized sewage treatment etc.	Developing climate forecasting and early warning systems, vulnerability analysis and adapting development investments for climate resilience, establish baselines, climate data gathering and monitoring for adaptive actions.
Baseline assessments, certification, and standard settings: eco-certification system, minimum performance and energy efficiency labelling programmes, green building & Building Management System (BMS), site-specific designing and planning for eco-industrial parks including baseline assessments, fuel economy labelling, transport sector baseline settings, MRVing of most technology-applications.	Establish sectoral databases, determine baselines, building climate information systems, establish long term monitoring plots for identifying climate-driven ecosystem changes, capacity building in the public health system in addressing climate change influenced diseases and health conditions.
R&D and knowledge transfer: vehicle performance and fuel economy labelling, energy efficiency testing of appliances, energy storage (grid and behind the meter), renewable energy resource development activities, precision agriculture, genetic improvement of herds/breeds of livestock and monogastric.	Research and development of new crop cultivars, enhanced productivity and agrotechnology, climate- resilient urban and coastal development, nature-based solutions for climate hazards, conservation of land and sea biodiversity etc.

Capacity building is also required to access climate finance through national institutions and the private sector. Private sector capacity building to develop innovative proposals on climate risk management and increasing capabilities within government and non-governmental organisations in Sri Lanka to design, cost, review and monitor climate actions leading to greater resilience is essential. Developing core capacities within the governance structure detailed below to support climate change-related awareness and communication; appraise projects, collect and disseminate data, monitor NDC-related progress and effectively communicate country-specific information, data and needs to international forums is urgently required.

Capacity development relating to data generation and data management is essential for all sectors implementing mitigation, adaptation and loss and damage related actions. The lack of adequately refined timely and standardized data hinders development planning and execution in general. Baselines. Recent climate and disaster- related assessments[62] demonstrate a lack of data on key indices to

[62] Third National Communication 2020; Post Disaster Needs Assessment 2016

determine losses and damages, vulnerability and adaptation capacity, sensitivity to climatic parameters etc.

There is significant scope to build capacity across sectors in Measuring, Reporting and Verification (MRV) of climate change actions and Monitoring and Evaluation (M&E) systems that support mitigation, adaptation, and loss and damage sectors. This is critical to deliver the 10-year NDC implementation and monitoring plans effectively and efficiently. Robust MRV systems will enhance investor confidence and improve resource mobilization opportunities. Some of the capacity needs specific to MRV/ M&E systems and resource mobilization include;

- Developing local climate vulnerability/resilience assessments using data and analytical tools;
- Tools and analysis to differentiate between business-as-usual development scenarios vs climate change impacts and forecasted impacts;
- BAU emissions scenario and potential GHG emission reduction pathways for some mitigation sectors and mitigation actions;
- Putting in place procedures to facilitate data availability to measure the impact (to measure change through time).

The consultations undertaken through the NDC revision process have created momentum for ongoing engagement in climate actions in each sector. It is important to recognize that technical knowledge resides with national experts and sector specialists. Any capacity building and effective application of technology for mainstreaming climate change must draw from the in-country experience and facilitate cross learning between climate change experts and subject matter experts from sectors. Building on the momentum created through the NDC revision process, it is important that sector specialists are enabled to guide the mainstreaming of climate actions (NDCs) into sectoral plans and strategies.

Implementation Mechanism

Sri Lanka has taken several steps to strengthen the country's readiness to face climate change. The Climate Change Policy of Sri Lanka (2012) provides the overarching framework that guides country priorities. In order to support NDC implementation and monitoring and to support the mainstreaming of climate actions into sectoral plans, Sri Lanka prepared a Readiness Plan 2016-2019 to identify and meet the pre-requirements for NDC implementation. The implementation and monitoring of the revised NDCs presented in this document will be supported through the below institutional framework (Figure 8.1), which builds on the experience of the Readiness Plan. This institutional architecture will be coordinated by the Ministry of Environment as the national focal point for the UNFCCC.

1) National Steering Committee for NDC Implementation

The Government of Sri Lanka will establish an inter-agency National Steering Committee (NSC) chaired by the Secretary, Ministry of Environment to oversee the implementation of NDCs. The NSC will have representation from secretaries of line ministries in charge of NDC sectors. Further, the NSC will have representation from and closely coordinate with the Ministry of Finance, National Planning Department, Department of Fiscal Policy, National Council for Sustainable Development.

The National Steering Committee will be responsible to oversee the implementation of NDCs in their intended manner, with adequate inter-agency cooperation on actions that require collaboration between multiple agencies. The NSC will further ensure policy coherence at the highest level, prevent duplication of efforts, present practical solutions to implementation barriers, monitor overall progress against timelines. From a national development perspective, it is important to consider synergies and development co-benefits between climate action and other sustainable development goals – including gender equality and women's empowerment. These are identified as preconditions for successful implementation of the Paris Agreement and the achievement of the SDGs[63]. Therefore, the NSC will ensure safeguards are in place for actions that may compromise SDG achievements, and liaise with the National SDG Council to report back on climate-related SDGs.

2) Ministry of Environment & Climate Change Secretariat

The Ministry of Environment is the national focal point for the UNFCCC. In 2008, the Climate Change Secretariat (CCS) was established as a dedicated division under this ministry. The CCS has since then instituted National Experts Committees (NECs) on Climate Change mitigation and adaptation, and an Inter-Agency Committee on Climate Change. The CCS was established to support the Ministry of Environment's role as the national focal point to UNFCCC and climate funds (Green Climate Fund and Adaptation Fund, etc.) and is tasked with developing national GHG inventories, supporting technology transfer to adaptation and mitigation sectors, facilitate the implementation of GHG reduction and resilience building actions, climate data and knowledge repository and dissemination. The CCS also develops regular communications to the convention and the Paris Agreement. Within this institutional structure, CCS will function as the facilitator, coordinator and communicator supporting implementation and monitoring of climate action.

3) Sectoral Planning and Monitoring Committees

Each NDC sector will have 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 will be fully integrated into the development plans currently being developed for each sector/line ministry covering the period 2021-2025/ 2030. Integration of climate actions into the regular planning framework of all sectors above, will ensure that the NDCs are prioritised for domestic/public financing or international donor assistance. Each sectoral PMC will be headed by the Secretary of the lead ministry and be tasked with executing h the NDC implementation plans with support from the government and private sector. Each PMC should make a detailed assessment of financial, technical, and capacity requirements for NDC implementation and ensure that these needs are communicated to the NSC and CCS. The Sectoral PMC is also expected to keep records of implementation bottlenecks and ensure safeguards are in place for climate actions that could compromise sustainable development.

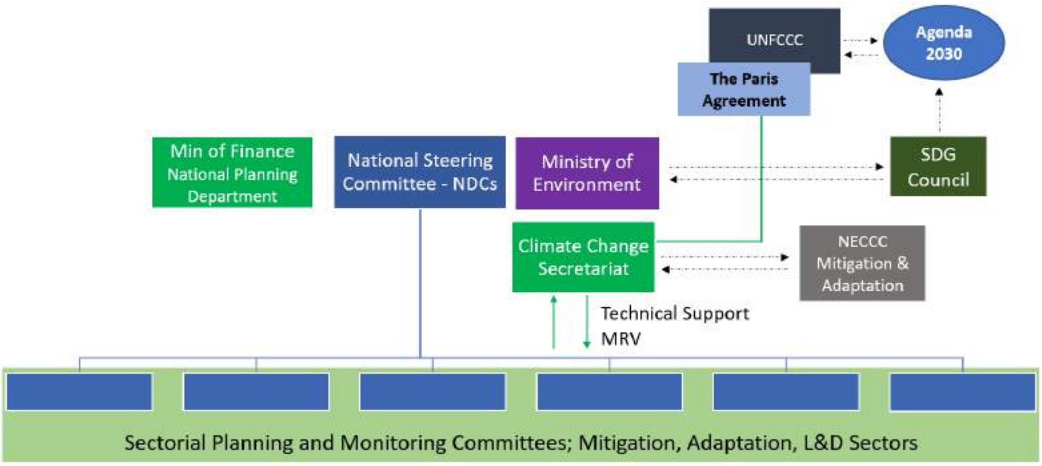


Figure 8.1: Institutional architecture for climate response

[63] UN Women, Leveraging Co-Benefits Between Gender Equality and Climate Action for Sustainable Development, Mainstreaming Gender Considerations in Climate Change projects, 2016

Acronyms

ADB - Asian Development Bank

AER - Agro-Ecological Regions

BAU - Business as Usual Scenario

BMS – Building Managing System

BRT - Bus Rapid Transit

BRT - Bus Rapid Transport

BtM - Behind-the-meter

CCC - Climate Change Secretariat

CCD - Department of Coast Conservation and Coastal Resource Management

CO_2 - Carbon dioxide

COP26 - 26th Conference of Parties

CSA – Climate-Smart Agriculture

DAD – Department of Agrarian Development

DoI – Department of Irrigation

DRM - Disaster Risk Management

DRR - Disaster Risk Reduction

DSM - Demand Side Management

DWC - Department of Wildlife Conservation

EAFM - Ecosystem-based Approach to Fisheries Management

EEI&C - Efficiency Improvement and Conservation Programme

EST - Environmentally Sustainable Transport

FD - Department of Forest Conservation

FMA - Fishery Management Areas

GBG - Green Building Guidelines

GCF - Green Climate

GDP - Gross Domestic Production

GFDRR- Global Facility for Disaster Reduction and Recovery

GHG - Greenhouse Gas

GSTC - Global Sustainable Tourism Council

GWh - Gigawatt hours

HEM - High-Efficiency Motors

HHAP - Heat – Health Action Plan

IAS - Invasive Alien Species

ICAT - Initiative for Climate Action Transparency

ICT - Information Communication Technology

IP - Industrial Parks

IPM - Integrated Pest Management

IPNS - Integrated Plant and Nutrition Systems

IPPU - Industrial Process and Product Use

IRBM - Integrated River Basin Management

ISO - International Organization for Standardization

L&D - Loss and Damage

LA - Local Authorities

LCA -Life-cycle assessment

LED - Light-emitting diode

LKR - Sri Lankan Rupee

LNG - Liquified Natural Gas

LRT - Light rail transit

M&E - Monitoring and Evaluation

MASL - Mahaweli Authority of Sri Lanka

MC - Municipal Council

MDGs - Millennium Development Goals

MoE - Ministry of Environment

MoH - Ministry of Health

MRV - Measuring, Reporting, and Verification

MSL - Mean Sea Level

MSW - Municipal Solid Waste

MT - Metric Tons

MW - Megawatt

NAMA - Nationally Appropriate Mitigation Actions

NAP - the National Adaptation Plan

NaPID - National Policy for Industrial Development

NAQDA- National Aquaculture Development Authority

NCD - Non-Communicable Diseases

NDC- Nationally Determined Contributions

NEC - National Experts Committees

NG - Natural Gas

NGRS - National Green Reporting System

NHSPEC - the National Strategic Plan for Health, Environment and Climate Change

NPP - National Physical Plan

NRW - Non-revenue Water

NSC - National Steering Committee

OAP - Overarching Agriculture Policy

PA - Protected Areas

PDNA - Post Disaster Needs Assessment

PDoL- Provincial Department of Irrigation

PES - Payment for Ecosystem

PMC - Planning and Monitoring Committee

R&D - Research & Development

RECP – Resource Efficient Cleaner Production

SDG - Sustainable Development Goals

SL GAP - Sri Lanka Good Agriculture Practices

SLR - Sri Lanka Railway

SLTDA - Sri Lanka Tourism Development Authority

SMART - Specific, Measurable, Achievable, Realistic, and Timely

STEM - Science, technology, engineering, and mathematics

TC – Technical Committee

THI - Temperature Humidity Index

TNC - Third National Communication

ToU - Time of Use

TROF - Trees Outside Forests

UC - Urban Council

UDA - Urban Development Authority

UN - United Nations

UNDP - United Nations Development Programme

UNFCCC - United Nations Framework Convention on Climate Change

USD - U.S. Dollar

VFD - Variable Frequency Drives

WMAWP - Waste Management Authority of Western Province

WP - Western Province

Annex VI

CARBON NET ZERO 2050

ROADMAP AND STRATEGIC PLAN

SRI LANKA

AUGUST 2023

MINISTRY OF ENVIRONMENT

CARBON NET ZERO 2050

ROADMAP AND STRATEGIC PLAN

SRI LANKA

FINAL REPORT

AUGUST 2023

MINISTRY OF ENVIRONMENT

Carbon Net Zero- 2050 Roadmap and Strategic Plan

ISBN

LIST OF ACRONYMS / ABBREVIATIONS

AFOLU	Agriculture-Forestry-Other Land Use
BAU	Business-as-usual scenario
ccGAP	Climate Change Gender Action Plan
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Utilization and Storage
CEA	Central Environmental Authority
CEB	Ceylon Electricity Board
CDM	Clean Development Mechanism
CH_4	Methane
CMC	Colombo Municipal Council
CO_2	Carbon Dioxide
CO_2eq	Carbon Dioxide Equivalent
DAPH	Department of Animal Production and Health
DOC	Degradable Organic Carbon
DSM	Demand Side Management
EPL	Environmental Protection License
EPR	Extended Producer Responsibility (EPR)
EU	European Union
FAO	Food and Agriculture Organization
GCV	Gross Calorific Value
GDP	Gross Domestic Product
GHGs	Green House Gases
HVDC	High Voltage Direct Current
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
LKR	Sri Lankan Rupees
LPG	Liquefied Petroleum Gas
LTGEP	Long Term Generation Expansion Plan
LULUCF	Land use, Land use Change and Forestry
MoE	Ministry of Environment
MoPE	Ministry of Power and Energy
MOU	Memorandum of Understanding
MSW	Municipal Solid waste
MSWM	Municipal Solid Waste Management
NAPPWM	National Action Plan on Plastic Waste Management
n.d.	No Date
NDCs	Nationally Determined Contributions
NEAP	National Environment and Action Plan
NEP	National Environment Policy (NEP)
NEPIO	Nuclear Energy Programme Implementing Organization
NG	Natural Gas

NO_x	Nitrogen Oxides
NSSWM	National Strategy for Solid Waste Management
NSWMC	National Solid Waste Management Center
NTC	National Transport Commission
ORE	Other Renewable Energy
O&M	Operational and Maintenance
PPP	Polluter Pays Principle
PRDS	Petroleum Resources Development Secretariat
RE	Renewable Energy
SBATs	Science Based Actions and Targets
SCP	Sustainable Consumption & Production
SDGs	Sustainable Development Goals
SLAEB	Sri Lanka Atomic Energy Board
SLSEA	Sri Lanka Sustainable Energy Authority
SDG	Sustainable Development Goals
SO_2	Sulphur Dioxide
SW	Solid Waste
SWDS	Solid Waste Dump Sites
SWM	Solid Waste Management
TNC	Third National Communication for Sri Lanka
UDA	Urban Development Authority
UNDP	United Nations Development Programme
US$	United States Dollar
VRE	Variable Renewable Energy
VSSFCW	Vertical Subsurface Flow Constructed Wetland
WtE	Waste to energy
WW	Wastewater
WWTPs	Wastewater Treatment Plants

LIST OF UNITS

g	Gram
Gg	Gigagram
GWh	Gigawatt Hours
kcal	Kilocalories
kg	Kilogram
kJ	Kilojoule
kW	Kilowatt
mg	Milligram
MJ	Megajoule
MT	Metric Tons = tonnes
Mt	Mega tonnes
MW	Megawatt
MWe	Megawatt Electrical

LIST OF FIGURES

LIST OF TABLES

LIST OF ANNEXURES

TABLE OF CONTENTS

LISTOF REPORT PREPARERS

Team Leader – Prof (Mrs) Niranjanie Ratnayake

Sector Experts

Prof Asanka Rodrigo – Energy Sector

Dr Loshaka Perera – Transport Sector

Dr H.R. Pasindu – Transport Sector

Mr Nimal Perera – Industry Sector

Prof Bandunee Atapattu – Waste Sector

Dr P.B. Dharmasena – Agriculture Sector

Prof Hemanthi Ranasinghe – Forestry Sector

Prof Prasanthi Gunawardena – Economic Sector

Prof Subhangi Herath – Social and Gender Sector

Assisted by:

Mr A Rajaratnam

Mr Nirodha Dissanayake

Miss Koushani Amarasinghe

Miss T.I.P.K.M. Wijayarathne

Miss P.H. Samarakkody

Mr M.D.P.L.P. Wijekoon

Mr S. Himanujan

Miss W.A.K.S. Fonseka

Mr Chandima Perera Gunasena

Miss V.M. Fernando

Miss H.W. Fernando

EXECUTIVE SUMMARY

BACKGROUND

Sri Lanka is an island nation, with a 65,610 km² area and a population of 22.16 million (2021), with the service sector making up 59.7% of GDP, 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 1.13 tonnes through a gradual increase from a value as low as 0.22 tonnes of CO_2 per capita in 1975, according to the Climate Watch (2020), World Resources Institute and the World Bank. 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 a cause for concern. The Third National Communication of Climate Change in Sri Lanka (TNC) (MoE, 2022), states that the carbon sequestration was higher than the GHG emission in the country up to 2004, and it is reversed from 2005 onwards. According to the Intergovernmental Panel on Climate Change (IPCC), to honour the Paris Agreement and limit global warming to well below 2 degrees Celsius (and pursue efforts to limit that increase to only 1.5 degrees), global carbon emissions should reach net zero by 2050 at the latest. In line with the above thinking, Sri Lanka has, in the updated NDCs of the Ministry of Environment (2021), committed to achieve its Carbon Neutrality by 2050. The development of the 2050 Carbon Net Zero Road Map and Strategic Plan for Sri Lanka is an attempt to realistically set the stage for reducing the GHG emissions and increasing carbon sequestration and storage to achieve carbon neutrality through climate actions covering the following six main thrust areas as identified in the NDCs: viz Energy, Transport, Industry, Waste Management, Agriculture and Forestry. The project is expected to formulate a comprehensive Road Map and a Strategic Plan that will 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, paying due attention to the gender inclusivity and socio-economic well-being of the community.

APPROACH AND METHODOLOGY

The approach of the study was to predict the GHG emissions from the anticipated activities in the six sectors of concern identified in the NDC's for GHG emission control over the period 2025 to 2050 in the Baseline and Mitigation Scenarios, developed using specific prediction models for each sector. The Baseline Scenario was defined as the future scenario where the predicted emissions in the NDC report for the Unconditional Actions were extended to the year 2050, continuing current trends in population, economy, technology and human behavior. A real GDP growth rate of 3.1% was used for the Baseline scenario, as per the Sri Lanka Government's Climate Prosperity Plan (2022). The Mitigation scenario was developed for each sector, by identifying the appropriate strategies, considering and selecting the appropriate unconditional and conditional mitigation actions identified in the NDC's, and additional interventions to reflect the best case of mitigation, technically, socially and environmentally feasible down the timeline, in each sector. Each sector specialist considered several options/pathways of mitigation actions under this scenario. 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 by the consultants, which went beyond the NDC actions, were to be implemented as proposed, in a timely manner. Therefore, the Mitigation Scenario was taken as the Net Zero Scenario. The Real GDP growth rate of 4.2% taken from the Sri Lanka Government's Climate Prosperity Plan (2022) was adopted for the Net Zero scenario.

Considering the importance of the need for acceptability of the Road map by the implementing agencies and administrative entities of the government, stakeholder consultation was a key element in the process of development of the Road map and Strategic Plan. Two stakeholder workshops were conducted with invited participants, covering implementing and administrative organizations from each and every sector, as well as members dealing with the gender and social/socioeconomic concerns in the implementing agencies and academia. The first workshop was aimed at opening lines of communication and gathering information on the baseline situation with regard to the existing and planned policies, strategies and action plans as well as staff, technology and infrastructure gaps in the stakeholder organizations and the participants' views on the mitigation actions as proposed in the NDCs. In the second stakeholder meeting, the participants were made aware of the future scenario of emissions, proposed mitigation actions and their views were obtained on the feasibility of proposed actions, new actions that could be considered and the institutional arrangements and new policies/ amendments to policies needed for the implementation of actions, strengths and weaknesses in the system and opportunities for improvement. The workshops were structured as sector wise group discussions, to extract the best ideas and responses form them for the study. In addition, informal interviews were held by the sector specialists, especially the sociology and gender specialist, to gather information on the gender and social analysis. A validation workshop of the proposed Strategic Plan and Road Map was held to a wider cross section of stakeholders, and their valuable comments and recommendations were incorporated into the Final Report. In the case of the Energy Sector, which, in fact is the highest contributor to GHG emissions at present, two optional pathways were considered, one pathway with the introduction of nuclear energy from 2035 and the other aiming at 100% Renewable Energy by 2050 without introduction of nuclear power, due to the uncertainty in the social acceptability of nuclear power in the country, as highlighted by some stakeholders at the validation workshop. Introduction of Green Hydrogen as a Renewable Energy source is also proposed as an option to be seriously considered.

The Policy framework for Climate Change is set by the National Climate Change Policy (MoE, 2014), which was developed to provide guidance and directions for all the stakeholders to address the adverse impacts of climate change efficiently and effectively. There are two important documents that were prepared by the Ministry of Environment and approved by the Cabinet in 2022, pertaining to the Government's Policy, strategies and action plans related to the environment, under the current context of Climate Change adaptation and mitigation. They are the National Environment Policy (NEP) 2022 and the National Environment Action Plan (NEAP) 2022 – 2030, both of which address the Climate Change Mitigation as well as Adaptation to Climate Change impacts. In addition, the Draft Low Carbon Development Strategy for Sri Lanka 2021-2030 has been developed by the Climate Change Secretariat of the Ministry of Environment (MoE, 2021b).

SECTOR WISE PREDICTION OF EMISSIONS FOR THE BASELINE AND MITIGATION SCENARIOS

The current situation with regard to the six sectors that are identified as main contributors to GHG Emissions, their role in the national development and the current status and past trends of GHG emission were analyzed and are given Section 2 of this Report. The Baseline Scenario for each sector was developed using the national level data on population prediction model adopted by the UN World Population Prospect 2022 (UN, 2022), and the real GDP values adopted in the Sri Lanka Climate Prosperity Plan (CPP) Preliminary report (V20, 2022).

THE BASELINE SCENARIO

The sector wise prediction of GHG emissions for the Baseline scenario were developed for the 2025 – 2050 period and is described in Section 3.2 of this Report. The overall situation of the emission predictions for the Baseline scenario is given in Figure 3.21 in the report and reproduced in the Executive Summary as Figure A.

The calculations showed that in the Baseline situation, where only the NDC unconditional actions that do not depend on external inputs such as technology and funding are implemented, by 2050, there will be a net carbon emission quantity of 23.62 Mt per year, resulting from a total emissions quantity of 46.03 Mt per year, while the expected sequestration would amount to 22.41 Mt per year.

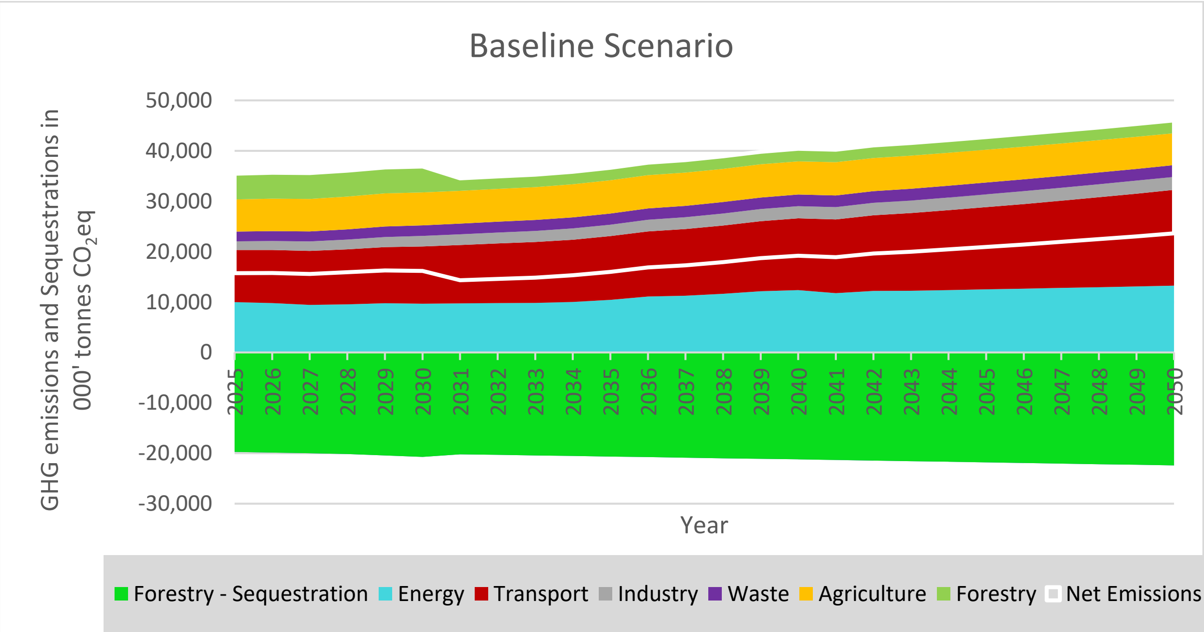


Figure A: The Cumulative Emissions and Sequestration for the Baseline Scenario

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

THE MITIGATION (NET ZERO) SCENARIO

After identifying the feasible mitigation actions for each sector, using NDC actions as an initial step, and studying literature, research findings and 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 team was able to model the GHG Emissions for the Best-Case scenario, which is taken as the Mitigation (Net Zero) Scenario.

The sector wise prediction of GHG emissions for the Mitigation (Net Zero) Scenario were developed for the 2025 – 2050 period and is described in Section 3.3 of this Report. The overall situation of the emission predictions for the Baseline scenario is given in Figure 3.30 in the report and reproduced in the Executive Summary as Figure B.

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 quantity of -8.604 Mt per year, as the total emissions will be reduced to 14.25 Mt per year, while the expected sequestration would amount to 22.85 Mt per year.

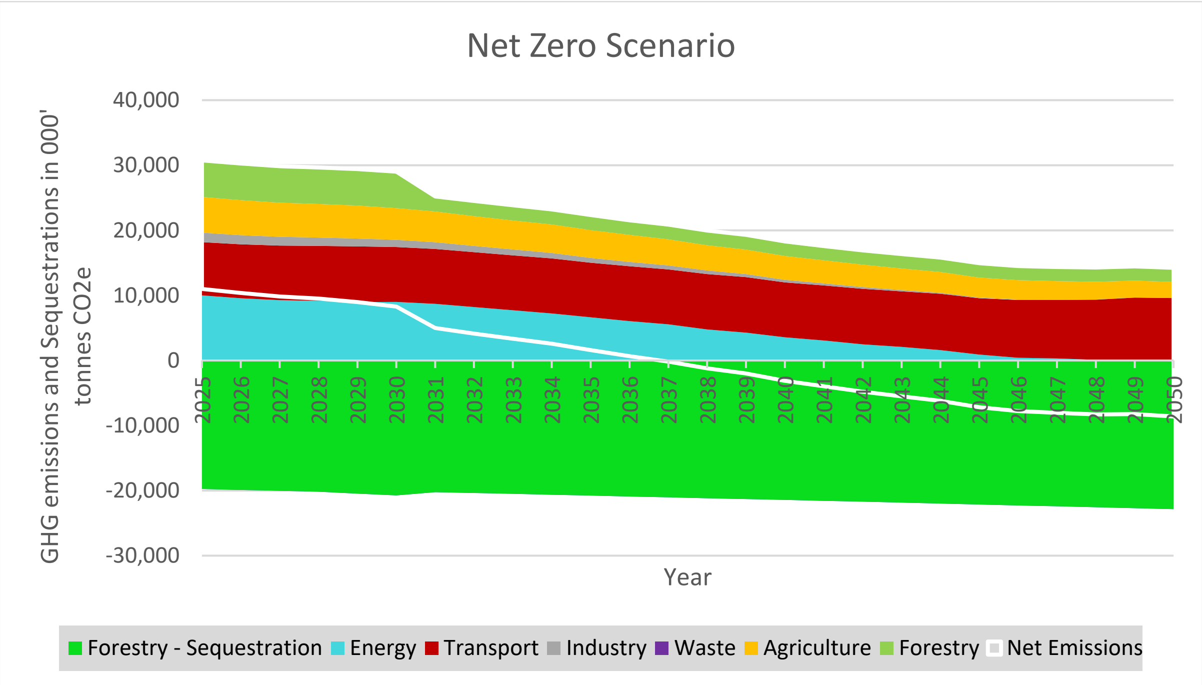


Figure B: The Cumulative Emissions and Sequestration for the Mitigation (Net Zero) Scenario

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

PROPOSED CARBON NET ZERO FRAMEWORK FOR 2050

Sri Lanka's Carbon Net Zero 2050 Roadmap has the Vision of "A CARBON NEUTRAL PROSPEROUS SRI LANKA".

According to the U.N. Climate Science Panel, man-made carbon dioxide emissions need to reach "net zero" by mid-century to give the world a good chance of limiting warming to 1.5 ^{0}C and avoiding the worst impacts of climate change. Transitioning to a carbon net-zero world is one of the greatest challenges the humankind has faced. Sri Lanka, being a developing country, cannot compromise economic and social development to achieve carbon net zero status. This is an effort to ensure a prosperous and secure country, which is not contributing to the global consequences of climate change caused by anthropogenic GHG emissions.

In order to achieve Carbon Net Zero by the year 2050, the sector wise feasible strategies and actions for reduction of emissions and increasing sequestration or trapping of carbon were studied in detail, so that mitigation actions could be proposed for each sector to achieve the maximum possible reduction in emissions, while maximizing the economic and social development of the country.

FEASIBLE STRATEGIES AND MITIGATION ACTIONS FOR ACHIEVING TARGETS

The feasible strategies and actions for achieving the emission reductions and increased sequestration were identified for each sector in consultation with the stakeholders, and review of literature to find innovative technologies available and methods used locally and overseas. The list of proposed strategies, actions and new technologies is given in Section 4.5 of this Report.

The gender and social impacts of the proposed actions were studied by the sociologist, and corrective action to eliminate any biases against vulnerable groups were suggested to avoid social and gender issues. It is noteworthy that, even though Sri Lanka is listed under the National Focal Points, the country so far has not followed the procedure to nominate a national gender focal point for climate negotiations (UNFCCC, n.d.). The requirement made by UNFCCC to establish gender focal points in relation to climate change under Climate Change Gender Action Plans (ccGAP) has never got implemented in policy planning in Sri Lanka, neither by Ministry of Women and Child Affairs nor by Ministry of Environment.

The issues and constraints for achieving the targets are discussed. The main issues highlighted are the lack of data management systems in most sectors, access to finances, technologies and need for capacity building of staff for implementing the proposed strategies and actions. Several Policy gaps were also identified, which need to be filled for successful implementation of the actions proposed in the Road map.

Following are some identified areas where policy directives are required for implementation of proposed strategies and actions to achieve carbon neutrality. These are described in detail in Sections 4.9.1 to 4.9.6 of the Report.

1. If the pathway with the introduction of nuclear power is to be taken, it is imperative that the following policy directives are initiated immediately:
    a. Promulgation of a new Act and Establishment of a new regulatory body with adequate human and other resources for regulation of Nuclear Power Plants.
    b. Amendment of the existing Sri Lanka Atomic Energy Act No.40 of 2014 to include regulation of nuclear power and strengthen the manpower and other resources.
    c. A clear and strong policy directive is necessary in the nuclear energy sector (similar to government no-coal policy) to incorporate nuclear power as mainstream scenario in the Long-Term Generation Expansion Plan (LTGEP).
2. The draft National Transport Policy which is under review since 2019 needs to be finalized soon and published by a gazette.
3. BOI industry policy (with a priority on investment promotion and economic development concerns rather than promoting low-carbon industry proposals) needs to be amended to promote low carbon industry proposals.
4. Provide sustainability guidelines in setting up individual industry/industry parks with appropriate sustainable economic analysis and incentives to promote the low-carbon industry.
5. National-level recognition of low-carbon industries and their sustainability impacts.
6. Policies for promoting/attracting low carbon options such as Co-generation / tri-generation, district heating/cooling, and benefits should be introduced.
7. The National Waste Management Policy should be amended to
    a. Improve the segregation of MSW at source and increase the number of segregations categories.
    b. Clearly define the purpose of waste-to-energy projects and plan the phasing out of preferential feed-in-tariffs.
    c. Introduce other thermal treatment technologies.
    d. Introduce Land-fill Gas recovery systems.
8. Policies should be introduced to regulate the establishment of new waste-to-energy facilities.
9. Operationalize policy and regulation for siting and implementation of sanitary landfills.
10. Update or introduce the required legislation to facilitate and enforce the implementation of NDCs.
11. Introduce a mechanism for waste generation forecasting with a tracking system to monitor the generation.
12. Introduce legislation to make segregation of waste at the household level mandatory.
13. Introduce or amend necessary legal framework and instruments to initiate Market-Based Instruments (MBIs) and non-market-based instruments to incentivize and promote sustainable consumption patterns.
14. Implement the “Polluter Pays Principle” for mixed waste generators.
15. Conduct awareness and capacity-building programs for behavioral changes in waste generators as well as waste management personnel.
16. Facilitate public-private-partnerships to finance waste sector mitigation actions.
17. Introduce new policies or amend existing policies to

a. include adoption of renewable energy in agriculture and livestock applications.
b. increase land use productivity, improve fertilizer use-efficiency and improve water use efficiency in coconut cultivation.

It was noted at the stakeholder meetings that the agencies responsible for the review of the policy on Irrigation and Land Use and make recommendations to minimize GHG emissions need resources such as finances, manpower, technical knowledge etc. to complete this task.

CARBON NET ZERO STRATEGIC PLAN AND ROAD MAP

The Strategic Plan and Road Map indicating the strategies and actions proposed to achieve the target emission reductions and increased sequestration necessary to achieve carbon Net Zero status as anticipated, before 2050, that was developed, is described in Section 5, and is depicted in Table 5.3.

The Road Map provides the series of strategies to be used and actions proposed to be carried out under each of the six sectors, in the five-year periods from 2025 to 2050. The estimated GHG emission reduction from the baseline emission level at the end of each five-year period due to the particular action/set of actions are also given as milestones, in the progress towards Carbon Net Zero and carbon positivity. The Key Performance Indicators (KPI's) are also indicated 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 need data, funding and technology inputs, to be taken into the emission reduction calculations at present. These 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 and better attitudes and conservation practices instilled in the population. The Road Map and Strategic Plan are expected to be used as a base document, with the achievement of milestones being monitored through the KPI's for the actions given for each sector. Thus, any significant deviations from the expected outcomes should be dealt with immediately, with corrective actions, within a short time period, before it is too late and too expensive to be reverted back on track.

NEED FOR INVESTMENTS TO ACHIEVE CARBON NET ZERO

In order to achieve Carbon Net Zero Status in Sri Lanka, a variety of mitigation options have been proposed for each sector, as shown in the above Strategic Plan and Road Map. Detailed calculations of economic benefits achieved by avoided Carbon emissions and the cost of implementation of the proposed actions are provided in the report. Table A gives a summary of the investments needed in the five-year periods from the present to the year 2050, in order to implement the proposed actions. It can be seen that the consultants have proposed actions that need minimum additional funding during the initial period under consideration, in recognition of the fact that the country is going through an economic crisis at the moment, and therefore until funds from external sources are secured, the spending on activities that are aimed at carbon emission reduction will have less priority than the spending on essential commodities.

The Central Bank of Sri Lanka, in their comments on the Draft Final Report of this Road Map, have stated that "Under the current Extended Fund Facility (EFF) of the International Monetary Fund, the Government is committed to maintaining a primary surplus from 2024 onwards. Given the rigid nature of the recurrent expenditure of the Government, curtailment of capital expenditure is 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 supporting incentives very early in the timeline.

The present value of the total investments required to implement the strategic plan is estimated at Rs 44,137 billion, which, at the present exchange rate amounts to approximately US$ 140 billion.

Table A: Investments required for proposed actions in 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

RECOMMENDATIONS

- It is acknowledged that the proposed action plan does not include any road map for financing the proposed strategic actions. The Central Bank of Sri Lanka, have recommended that in order to facilitate and ensure the timely implementation of the action plans, the key focus should be on alternative financing options than on budgetary allocations. It is recommended that green financing options available locally and internationally should be investigated and approached for funding the investments needed to achieve the desired outcomes.
- The Central Bank of Sri Lanka has already prepared a 'Green Finance Taxonomy' for the Sri Lanka's banking sector, with the aim of promoting lending through the domestic financial system to green projects. Therefore, seeking concessional or priority-based funding for zero carbon projects from the banking sector could be considered as a financing option going forward.
- Implementation of the actions proposed to achieve Carbon Net Zero involves the participation of state as well as private sector institutions, as well as individual citizens, and it is important that a high level of participation is forthcoming from all stakeholders.

- To ensure sustainable growth, investing in research and development becomes 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 the carbon emissions, which will further attract innovation and drive industry expansion.
- While much effort has been taken to include the opinions of the decision-making officials in the government sector in the development of the strategic plan, through stakeholder consultations, this being a long-term plan, needs to be regularly updated with data available in the future. The government should encourage an open dialogue with all stakeholders and monitor the achievement of the Key Performance Indicators on a regular basis, at least biennially, and review the Strategic Plan and Road Map accordingly.
- As stated in the National Climate Change Policy, it is imperative that the Climate Change is mainstreamed and integrated in the National Development Process. The strategies and actions proposed in the Strategic Plan and Road Map will need to be internalized into the development plans of the relevant institutions, in order to achieve the vision of "A CARBON NEUTRAL PROSPEROUS SRI LANKA".

SECTION 1 - BACKGROUND

1.1 Background and the objective of the study

Sri Lanka is an island nation, with a 65,610 km² area and a population of 22.16 million (2021), with the service sector making up 59.7% of GDP, the industrial sector 26.2%, and the agriculture sector 8.4% according to Ministry of Economic Policies and Plan Implementation (2021). The function of several sectors such as energy, transport, agriculture, industry, forestry, and waste management are emitting large quantities of GHGs, contributing per capita emissions of around 1.02 tonnes/per person.

In 2020, CO_2 emissions per capita for Sri Lanka had reached a value of 1.13 tonnes through a gradual increase from a value as low as 0.22 tonnes of CO_2 per capita in 1975, according to the Climate Watch (World Resources Institute and the 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 a cause for concern. In the updated Nationally Determined Contributions (NDCs) published by the Ministry of Environment in July 2021, it is stated that 'Despite the low carbon footprint and high vulnerability to climate change, Sri Lanka commits to reducing its GHG emissions'. In these NDCs, the country presents an enhanced ambition which includes 4% unconditional and 10.5% conditional emission reduction commitments with respect to the Business-As-Usual (BAU) scenario.

According to the Intergovernmental Panel on Climate Change (IPCC, 2021), in order to honour the Paris Agreement and limit global warming to well below 2 ^{0}C (and pursue efforts to limit that increase to only 1.5 ^{0}C), global carbon emissions should reach net zero by 2050 at the latest. Over 100 countries have already pledged to do this. However, on its own, reaching net zero in 2050 is nowhere near enough. According to the UNEP, in order to limit global warming to no more than 1.5 ^{0}C, the whole world would need to reduce emissions by 7.6 % per year every single year between 2020 and 2030 (UNEP Press Release 26 November 2019). Even limiting global warming to well below 2 ^{0}C would require annual global reductions of greenhouse gas emissions of 2.6 percent per year. It is important that the action to reduce emissions should start early, rather than wait till the end of the period to achieve the goal, as the short-term impacts could result in climate catastrophes. Thus, the net zero target by 2050 should be complemented by short-term targets too, and all contributing sectors of the economy should be covered.

In line with the above thinking, Sri Lanka has, in the updated NDCs of the Ministry of Environment (2021), committed to increasing the forest cover to 32% by 2030 and reducing greenhouse emissions by 14.5% for the period of 2021–2030 from Power (electricity generation), Transport, Industry, Waste, Forestry, and Agriculture sectors. These targets are determined by considering the achievement of 70% renewable energy in electricity generation by 2030 to achieve Carbon Neutrality in electricity generation by 2050 and assuming there will be no capacity addition of coal power plants in the country. According to the above document, Sri Lanka expects to achieve its Carbon Neutrality by 2050.

The Glasgow Climate Pact called on all countries to revisit and strengthen the 2030 targets in their NDCs by the end of 2022, to align with the Paris Agreement temperature goal. If the overall Carbon neutrality (Net Zero) has to be achieved by 2050 for Sri Lanka, the targets given in the updated NDCs in 2021 have to be further updated, and the strategies and roadmap have to be prepared for achieving these.

The development of the 2050 Carbon Net Zero Road Map and Strategic Plan for Sri Lanka, is an attempt to realistically set the stage for reducing the GHG emissions and increasing carbon sequestration and storage to achieve carbon neutrality through climate actions covering the following six main thrust areas as identified in the NDCs (MoE, 2021 a):

- Energy
- Transport
- Industry
- Waste Management
- Agriculture and
- Forestry

1.1.1 Scope and Objectives

The project is expected to formulate a comprehensive Road Map and a Strategic Plan that will 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. A well-developed set of policy guidelines anchored on the strategic plan to be developed will cover the Road Map for achieving Carbon Net Zero by 2050, to be given proper statutory acceptance across all levels of the administrative entities of the Government of Sri Lanka.

Carbon net zero refers to the balance between the amount of C produced and the amount removed from the atmosphere, or activities that releases net-zero carbon emissions into the atmosphere. If a country is to reach carbon-net zero, it must primarily reduce its emissions of greenhouse gasses into the atmosphere and increase its carbon dioxide-absorbing ecosystems.

The six sectors mentioned above will be covered in terms of potential carbon emission reduction, enhanced absorption, and sequestration, contributing to the net zero processes. The main concerns and related actions are briefly explained further below.

The Third National Communication of Climate Change in Sri Lanka (TNC) (MoE, 2022), states that the carbon sequestration is higher than the GHG emission in the country up to 2004, and it is reversed from 2005 onwards. The data given in the TNC Report shows that this change has taken place both due to the increase in emissions as well as the decrease in net sequestration of Carbon over the years during the period 2000 to 2010, which was under consideration in the TNC Report. According to the TNC, when considering the emissions excluding the Land Use, Land Use Change and Forestry (LULUCF), in 2010, out of a total of 22.08 Mt emissions, the Energy sector including Transport contributed 64.1% and the agriculture sector contributed 29.5%, while waste and industry (IPPU) sectors contributed 4.4% and 2% respectively. When LULUCF emissions are also included, the profile changes to nearly 50% (49.3%) contribution coming from the LULUCF sector, 32.5% from the Energy sector and 15% from the agriculture sector, while the waste and IPPU contribution contributions are reduced to 2.2% and 1% respectively. However, 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 according to the TNC (MoE, 2022).

Women are still under-represented in the climate change decision-making process in Sri Lanka as well as in many other parts of the world. Gender inequity is a cross-cutting theme affecting development programs. Ironically, it is well established that the climate change impacts are disproportionately affecting women. Thus, it is important that special attention is paid to ensure that women are included in the educational programs on technologies and mechanisms aimed at attaining Net Zero Carbon, as well as in the implementation of actions. 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 available 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 measures (World Bank and CIAT, 2015; Huyer, 2016; Milazzo and Goldstein, 2017)

1.2 Link with the National Vision on Climate Change

The National Climate Change Policy of Sri Lanka (MoE, 2014) contains a vision, mission, goal, and a set of guiding principles followed by broad policy statements under Vulnerability, Adaptation, Mitigation, Sustainable Consumption & Production, Knowledge Management and General Statements. Collaborative action at all levels is necessary to transform this policy into a meaningful set of actions to meet the challenges of climate change. The Vision, Mission and Goal of the National Climate policy are defined as follows:

Vision: A future where climate change will have no adverse consequences on Sri Lanka.

Mission: Addressing climate change issues locally while engaging in the global context

Goal: Adaptation to and mitigation of climate change impacts within the framework of sustainable development

The National Climate Policy has the following stated as its objectives:

1. Sensitize and make aware the communities periodically on the country's vulnerability to climate change.
2. Take adaptive measures to avoid/minimize adverse impacts of climate change to the people, their livelihoods, and ecosystems.
3. Mitigate greenhouse gas emissions in the path of sustainable development.
4. Promote sustainable consumption and production.

5. Enhance knowledge on the multifaceted issues related to climate change in the society and build their capacity to make prudent choices in decision making.
6. Develop the country's capacity to address the impacts of climate change effectively and efficiently.
7. Mainstream and integrate climate change issues in the national development process.

Thus, the development of the Road map and Strategic Plan for achieving Carbon Net Zero in a sustainable manner is a mandatory part of achieving the objectives of the National Climate Policy, particularly Objectives 3, 4 and 7,

Sri Lanka, being a party to the Paris agreement has made a commitment of reaching Net Zero status by 2050, in the updated Nationally Determined Contributions (NDCs) submitted to the UNFCCC in 2021, as a mandatory requirement of the agreement. This Roadmap and Strategic Plan are developed to provide a clear vision of the way in which the country must move, in order to reach the goal, as committed to the UNFCCC.

Recognizing the need for responding to the challenges faced by the developing countries which are also the most vulnerable to Climate Change impacts (V20), the member countries of Climate Vulnerability Forum (CVF) have developed Climate Prosperity Plans, which are aimed at designing actionable investment and implementation pathways for climate action.

The Preliminary Report of Sri Lanka's Climate Prosperity Plan 2022 (V20, 2022) outlines a national investment strategy for climate-proofing the nation, and in doing so to secure Sri Lanka's pathway to prosperity in a climate-insecure world. It mentions three goals and three objectives under each goal.

Goal 1 - Unlock domestic energy abundance through renewables, modernization, and sustainable transport

Goal 2 - Financially engineer a climate-secure transportation

Goal 3 - Galvanize climate protection against key risks

These goals and objectives are very much in line with the aspiration of the development of the Roadmap to Net Zero by 2050. For example, the objectives under goal 1 include financing maximized renewable energy and grid modernization potential and connectivity and sustainable transportation by supporting renewable energy-based, resilient mobility network and promoting sustainable lifestyles; goal 2 includes repurposing and reducing the debt-for-climate swaps, carbon financing to value blue carbon, soil carbon, forest carbon, etc.

Implementing these actions will promote the move towards Carbon Net Zero status that is being envisaged in this roadmap, and the actions proposed in the roadmap will play a complementary role in achieving the objectives of the CPP for Sri Lanka.

The Carbon Net Zero 2050 Roadmap has the component of developing mechanisms towards balancing emissions with their input and output rates, with room for path correction, as milestones are traversed in time frame. In other words, the entire Carbon Net Zero 2050 Project is leveraged on a quantifiable platform to count emissions, releases, abatement, and sequestration. Once the Road map and plan are accepted by the stakeholders who would include the parties responsible for implementing the proposed actions and the agencies monitoring the outcomes of the actions, it would provide the pathway for sustainable development of the country, aligned with the United Nations' call for national efforts to control the GHG emissions to keep the global warming well within 2 ^{0}C.

1.3 Approach and Methodology

The process followed in the preparation on this report is given in the Figure 1.1

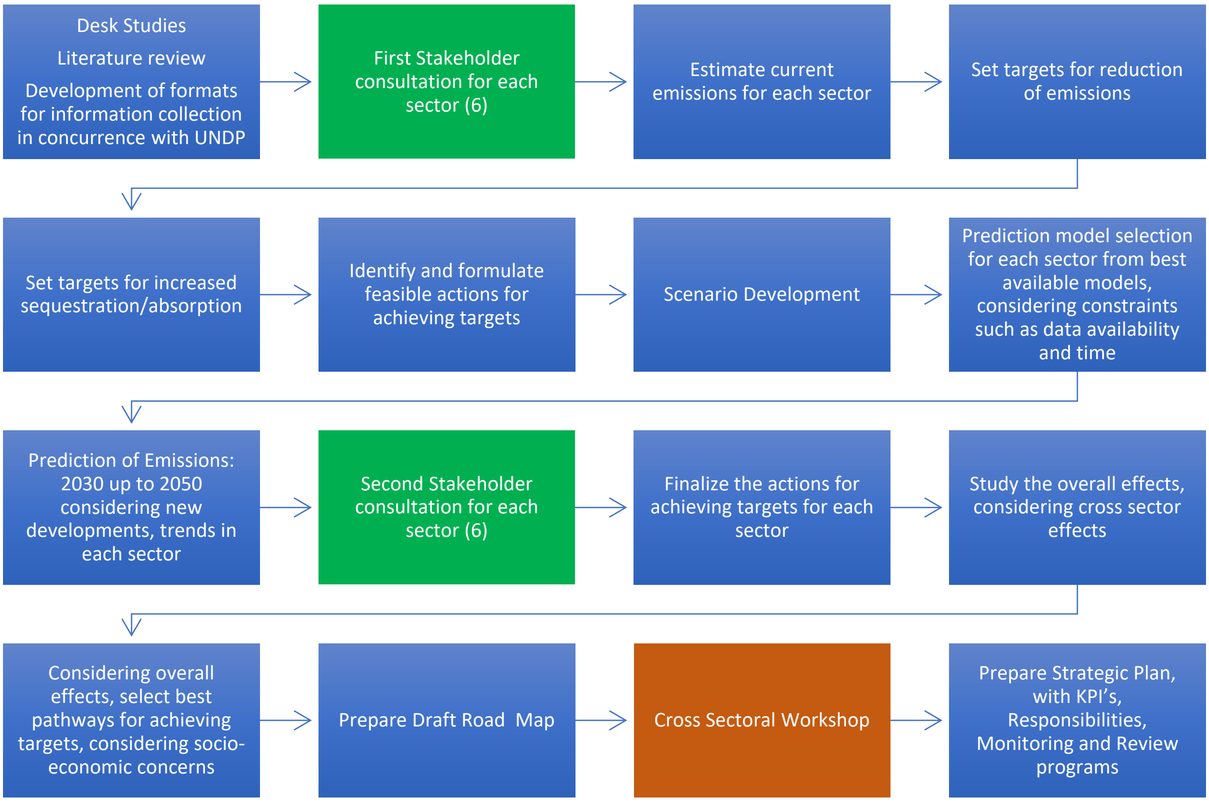


Figure 1.1 : Process Flow Chart

General Methodology

The overall objective of this assignment is to develop a 2050 Carbon Net Zero Road Map with a Strategic Plan for Sri Lanka, in consultation with relevant stakeholders from the respective sectors. The sector specialists for the six sectors studied the current status of GHG emissions and the related policy background in their respective sectors in Sri Lanka and proposed feasible strategies and actions to minimize emissions and increase sequestration/ capture carbon in the period 2025 to 2050, through review of literature, discussions and consultations, and using their expert knowledge in the field. The updated NDC Report (MoE, 2021) provided background information for the study, to understand the past trends and predictions up to 2030. However, the sector specialists reviewed the proposed actions in the NDC report, and selected to carry forward only those that they could reasonably justify as feasible, and proposed some other strategies and actions too, to achieve Carbon Net Zero by 2050. The calculation of emissions in terms of tonnes of CO_2 equivalent were carried out using the IPCC Guidelines (IPCC, 2006) and projections of emissions were carried out using accepted long term forecasting techniques for population and economic growth. The social and gender specialist analysed the situation with respect to social impacts due to the proposed actions and made recommendations to assure social and gender equity and inclusivity in the strategies and actions proposed in the Road Map. An economic analysis was carried out to check the economic viability of the proposed actions for each sector with respect to the value of avoided Carbon, and recommended policy directions for successful implementation of the Road Map and Strategic Plan.

Literature review

- The following documents were used for the base line data as well as for the scenarios development:
  - Nationally Determined Contributions, Ministry of Mahaweli Development and Environment Sri Lanka (2016)
  - Readiness Plan for Implementation of Intended Nationally Determined Contributions (INDCs) 2017-2019, Ministry of Mahaweli Development and Environment Sri Lanka (2016)
  - *Updated Nationally Determined Contributions under the Paris Agreement on Climate Change Sri Lanka,* Ministry of Environment, Sri Lanka

- The following was used as the base documents for the calculation quantities of national level sectoral GHGs emission:
  - IPCC Guidelines for National Greenhouse Gas Inventories, 2006

- The following documents were used as key references for the study:
  - Initial National Communication under the United Nations Framework Convention on Climate Change, MoE (2000)
  - Second National Communication on Climate Change MoE (2011)
  - Draft Low Carbon Development Strategy for Sri Lanka 2021-2030, MoE (2021b),
  - Third National Communication, MoE (2022)
  - Third National Communication of Climate Change in Sri Lanka MoE (2022b)
  - National Environmental Action Plan Pathway to Sustainable Development, 2022-2030: MoE (2022d)

  In addition, a large number of references were used to prepare this document. The list of documents used are given under References in Section 6 of this report.

Consultations:

- The project was initiated with the Kickoff meeting with the Ministry of Environment, Climate Change Secretariat, UNDP on August 16, 2022.

- Several informal interviews with the relevant organization were conducted by the sectoral experts to collect necessary information and their involvement, issues and constrains faced when implementing the NDC and other Climate Change related activities.

Stakeholder meetings

1st Stakeholder Workshop:

The first stakeholder meeting was held on September 23, 2022

The objective of the meeting was to ascertain baselines, sectoral plans, and priorities for emissions reduction and Sequestration opportunities from government proponents for the six identified mitigation sectors, toward achieving carbon net zero by 2050. The agenda and the list of participants are given in Annexure 1.

2nd Stakeholder workshop

The second stakeholder meeting was conducted on November 17, 2022. The aim of meeting was:

a) Briefing the progress of the preparation of the 2050 Carbon Net Zero Road Map and Strategic Plan.
    - Identification of the baseline scenario: Considering the NDC scenario with only unconditional actions as the baseline
    - Calculated emission predictions in the baseline scenario (With graphs showing the predictions up to 2050)
    - Considered scenarios and drivers which are used in the scenario development
    - Mathematical model used for the predictions up to 2050
    - Proposed mitigatory actions with timeline to bring down the emissions and increase storage/sequestration according to your plan
    - Gaps found in the first stakeholder workshop
        - Policy/ Strategy
        - Staff
        - Technology
        - Infrastructure
b) Discussion of the feasibility of the proposed actions and the timeline according to the stakeholders' opinions
c) New actions and timelines proposed by the stakeholders
d) Available regulatory framework for the implementation of proposed actions and any gaps
e) Identify institutional arrangements and new policies/ amendments to policies needed for the implementation of actions, strengths and weaknesses in the system and opportunities for improvement

f) Conduct a SWOT analysis within the sector for the 2050 Carbon Net Zero Road Map and Strategic Plan.

The agenda and the participant list are given in Annexure 1

Informal interviews – In addition to the stakeholder consultations, informal interviews were held by the sociology and gender specialist. These interviews were conducted with a purposive sample of respondents. Two samples were selected from two locations, urban and rural. The sample was further stratified according to the social class, upper middle and middle class as one and low-income communities as the other. Ten respondents from each sample group were purposely selected to discuss their everyday life and its possible contribution to GHG emissions and the impact of the climatic conditions on their lives.

Validation workshop

This will be conducted after submitting the draft final report

Limitations

The main limitation faced by the consultants was the difficulty in obtaining reliable data required for the estimation of GHG emission from the various sector activities. In most cases, information such as types and age of vehicles in the transport sector, raw material usage in the industry sector, waste volumes and characteristics in the waste sector are either completely missing, unreliable or only partially available, so that the estimation of GHG emissions had high uncertainty. An exception was the Energy sector, where the key organizations such as the CEB, SLSEA and PUCSL have good databases which could be accessed by the sector consultant without difficulty.

Another limitation that was faced by the study team was the fact that information that would be useful for this study was being developed by a few other studies that were undertaken simultaneously, and although there was a fair amount of exchange of information and ideas among the study groups, the findings of the other groups could not be verified, as they were still being processed.

Process followed for the preparation of the report

Figure 1.2 : Process Followed for the Preparation of the Report

1.4 Existing policies, strategies and action plans related to achieving net zero status of Sri Lanka

The National Climate Change Policy, as described in Section 1.2, was developed to provide guidance and directions for all the stakeholders to address the adverse impacts of climate change efficiently and effectively.

There are two important documents that were prepared by the Ministry of Environment and approved by the Cabinet in 2022, pertaining to the Government's Policy, strategies and action plans related to the environment, under the current context of Climate Change adaptation and mitigation. They are the National Environment Policy (NEP) 2022, the National Environment Action Plan (NEAP) 2022 – 2030.

In addition, the Draft Low Carbon Development Strategy for Sri Lanka 2021-2030 has been developed by the Climate Change Secretariat of the Ministry of Environment (MoE, 2021b).

- **National Environment Policy (2022)**

The NEP was prepared under the context of Sri Lanka aiming to become a low-carbon, climate-resilient green economy by adopting sustainable development policies.

The Policy identifies 13 Goals that form the basis of the policy objectives, out of which Goal No 8 specifically refers to the country being placed in a path of low-carbon development by implementing appropriate mitigation measures in the priority sectors of Energy, Transport, Industry, Waste and Agriculture-Forestry-Other Land Use (AFOLU) with high Greenhouse Gas (GHG) reduction potential.

Climate Change and Global Environmental Challenges are addressed in the Policy Statements given in Section 4.5 of NEP, which are further elaborated into subsections which broadly cover technical solutions, incentives-positive and/or negative-to create enabling environment for those solutions as well as institutional mechanisms for their implementation. The following five subsections refer to Climate mitigation actions:

4.5.1.5. Commitment towards meeting global GHG mitigation targets will be fulfilled by implementing appropriate mitigation measures in priority sectors with high GHG reduction potential.

4.5.1.6. Measures for reduction of GHG emissions will be selected to maximize co-benefits such as improvement of environmental quality, increased energy security, enhanced food security, reduced dependency on imported fossil fuels and enhanced health benefits by promoting options that include but are not limited to;

- Improving energy efficiency
- Renewable energy
- Integrated transport solutions
- Low and zero-emission vehicles including nonmotorized vehicles
- Integrated solutions of waste management
- Reducing Emissions from Deforestation and Degradation of forests (REDD)
- Adoption of appropriate Climate-Smart Agriculture (CSA) practices with mitigation co-benefits
- Use of traditional methods for food preservation and storage
- Resource-Efficient Cleaner Production (RECP)
- Climate-friendly cooling substances

4.5.1.7. An integrated system for Measurement, Reporting and Verification (MRV) of GHG emissions at national, sector and facility levels will be established to enhance the planning of mitigation efforts and facilitate the reporting of GHG emissions and emission reductions.

4.5.1.8. Prospects for harnessing Carbon Pricing Instruments (CPIs) represented by emission trading schemes and carbon taxes will be explored and necessary measures will be initiated to establish a globally integrated national carbon market for transacting carbon credits.

4.5.1.9. Measures will be initiated to introduce a 'Climate Change Impact Assessment (CCIA)' as a part of Strategic Environmental Assessment (SEA) and Environmental Impacts Assessment (EIA) procedures in evaluating investment plans and projects on which climate change is deemed to have significant implications for identifying and quantifying positive and negative contributions of projects to GHG emissions (mitigation impact) and positive and negative contributions to overcome critical impacts of climate change (adaptation impact).

- **National Environmental Action Plan 2022 - 2030**

The National Environment Action Plan (NEAP) 2022-2030 provides the strategies and action plans aligned with the National Environment Policy of 2022, to address environmental challenges of the 21st century and to achieve sustainable development aligned with the UN Sustainable Development Goals (SDGs).

Out of the nine thematic areas in the Action Plan, Thematic Area 3: Climate Action for Sustainability is developed to directly respond to the Thematic Area 4: Climate Change and Global Environmental Challenges of the NEP. It will strive to steer development along a low-emission trajectory, that supports both mitigation and adaptation to climate change, with a strong focus on reaching high income and human development in the next decade.

The action plan for this thematic area includes six strategies and 121 actions to meet the expected objectives for climate change, out of which there are 40 actions related to Energy, Industry, Waste, Transport, Forestry and Agriculture & Livestock sectors under Strategy 3: Reduce greenhouse gas emissions through low carbon development pathways.

In addition to the NEP and NEAP, several other documents prepared by the Climate Change Secretariat of the Ministry of Environment, viz First, Second and Third National Communications on Climate Change in Sri Lanka and the Updated Nationally Determined Commitments (2021) submitted to the UNFCCC, being a mandatory commitment of signatories to the Paris Agreement, also depict strategies and actions related to achieving net zero status of Sri Lanka across all sectors.

The sections 1.4.1 to 1.4.6 provide brief details of existing policies, strategies and action plans pertaining to the sectors, that have a bearing on the status and proposed actions for achieving GHG Emission reduction in the particular sector.

- **Draft Low Carbon Development Strategy for Sri Lanka 2021-2030 (MoE, 2021)**

Further to the Paris Agreement (2016), and to support the NDC Process in achieving its goals, a Zero Carbon Strategy had been proposed all over the world and Sri Lanka is one of the countries who had pledged to achieve this by 2050. To facilitate this process, the Climate Change Secretariat of the Ministry of Environment has prepared a document on Low Carbon Development Strategy which covers the following objectives:

- Promote low carbon technologies in all economic sectors through technology transfer and development.
- Reduction in fossil fuel dependencies through the energy savings, increasing energy efficiency and enhancing use of renewable energy sources.
- Provide efficient and effective sustainable transportation system with minimum GHG emission and improve the local air quality and ensure long life through good health.
- To enable Sri Lanka to effectively contribute to the global goal on mitigation, with a view to achieving sustainable development through the low carbon pathways.

- To build the capacity of key economic sectors and relevant institutions to address low carbon development pathways and promote green jobs.
- Development of afforestation and reforestation to enhance carbon sequestration.
- Cross-cutting issues, including the establishment and implementation of awareness creation programs, establishment of adequate research capacity for various R&D and training institutions, and promoting effective documentation of indigenous knowledge on low carbon development pathways in diverse sectors.
- Poverty reduction - Attracting investment for low carbon economic development and hence increasing GDP

1.4.1 Energy Sector

1.4.1.1 Existing policies in Energy Sector

After almost a decade since the introduction of the first documented energy policy directions in 1997, the government adopted the "Energy Policy and Strategies of Sri Lanka" in 2008. Though there was an energy policy prior to 2008, most of the policies governing the energy sector were more on an ad hoc basis, depending on the vision of the government at the time. One such example was the decision of the government to open grid-connected small hydropower (below 10 MW) sector for private investment in 1992.

The "Energy Policy and Strategies of Sri Lanka-2008" was revised as "National Energy Policy & Strategies of Sri Lanka" by the Extraordinary Gazette No. 2135/61 dated 2019-08-19. The main objective of this policy was to ensure the availability of convenient and affordable energy services for equitable development of Sri Lanka using clean, safe, sustainable, reliable and economically feasible energy supply. This Policy supersedes all previous policies, strategies, plans and guidelines published from time to time. This current Policy is formulated in alignment with the future goals of Sri Lanka, current global trends in energy and the Goal 7 of the Sustainable Development Goals of the United Nations. This policy is expected to realize the vision of Sri Lanka in achieving carbon neutrality by 2050.
The National energy policy stands on following ten pillars, to ensure the equity, security and sustainability in the energy sector in Sri Lanka.

- Assuring Energy Security
- Providing Access to Energy Services
- Providing Energy Services at the Optimum Cost to the National Economy
- Improving Energy Efficiency and Conservation
- Enhancing Self Reliance
- Caring for the Environment
- Enhancing the Share of Renewable Energy
- Strengthening the Governance in the Energy Sector
- Securing Land for Future Energy Infrastructure
- Providing Opportunities for Innovation and Entrepreneurship

The National energy policy and implementing strategies will be in effect until it is reviewed in consideration of any major changes in the external environment. Such policy reviews will be conducted at least once in six years, and this is considered as the apex energy policy in Sri Lanka.

Furthermore, specifically for the electricity sector, as per the Section 5 of Sri Lanka Electricity Act, No 20 of 2009, the Minister of the line ministry has the power to formulate the General Policy Guidelines on the Electricity sector for the Public Utilities Commission. The General Policy Guidelines on the Electricity Industry 2021 (issued in January 2022) set the targets of achieving 70% of electricity generation in the country using renewable energy sources by 2030 and carbon neutrality in power generation by 2050 and has decided to cease building of new coal-fired power plants. The Cabinet of Ministers has approved these two policy elements that shall form the basis of Sri Lanka's future electricity capacity expansion planning. Further, new addition of firm capacity will be from clean energy sources such as natural gas and nuclear power.

The opening up of the small hydropower sector to private entrepreneurs in 1992 and subsequent energy policy actions in the renewable energy sector and energy efficiency and conservation resulted in the government enacting legislation to establish the Sri Lanka Sustainable Energy Authority (SLSEA) in 2007 as the central institution for renewable resource development, energy efficiency and conservation. As per the SLSEA Act, they are empowered to identify, assess, and develop renewable energy resources, with a view to enhance energy security and thereby derive economic and social benefits to the country. Furthermore, they are the apex body to identify and promote, facilitate, implement, and manage energy efficiency programs for use of energy in the domestic, commercial, agricultural, transport, industrial and other relevant sectors.

1.4.1.2 Strategies and action plans in Energy Sector on achieving net zero status in Sri Lanka

Following key mitigation actions are considered as the strategies to reduce GHG emissions in energy sector.

- 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 600 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.

Proposed Strategies and action plans in Energy Sector related to the above are given in Table 1 in the Annexure 2.

Given the government's current indecision regarding the development of nuclear power plants in the country, exploring alternative strategies becomes crucial. One promising approach is to focus on achieving 100% indigenous renewable energy generation, complemented by efficient energy storage solutions.

Alternative Strategy:

- Decommissioning of all coal power plants by 2044
- No NG plant additions after 2033
- 100% RE share in the energy sector by 2050.
- HVDC inter connection to be introduced by 2034.

Proposed Strategies and action plans in Energy Sector related to the above are given in Table 1 in the Annexure 3.

However, the Long-Term Green Energy Plan (LTGEP) for the period 2023-2042 has shed light on some significant challenges in realizing an 80% renewable energy (RE) share by 2040. Notably, there have been concerns about RE spillage reaching uneconomical levels, hindering the attainment of the desired 80% RE share. The inability of the projected demand profile to absorb the renewable energy generation has resulted in a considerable amount of renewable energy being curtailed, even at an 80% RE share. This raises valid concerns about the practicality of scaling beyond this threshold, as it leads to a substantial increase in investment costs compared to the Base Case and raises doubts about the sustainability of operational expenses.

In light of these findings, it is evident that careful consideration and innovative approaches are essential for achieving a sustainable and economically viable renewable energy future for the country. Policymakers should strive to strike the right balance between renewable energy integration, efficient energy storage, nuclear power plant policy and the overall energy demand to ensure a successful transition towards a greener and more sustainable energy landscape.

1.4.2 Transport Sector

The lack of a national transport masterplan has been a hindrance to accurately forecasting an Emissions Management and Forecast program in the formation of strategy for Net Zero Carbon. Given the present economic conditions of the country, the implementation of projects that require major capital investments is doubtful for the next 5 years.

Yet, some headway has been cast thanks to the declared NDC's in the sector and national plans that have been formatted at ministry and agency levels of the government. 13 NDCs are proposed covering the key sub sectors in the transport sector: (MOE,2021 (a))

1. Transport sector system improvements.
2. Promote public passenger transport
3. Shift freight to efficient modes
4. Rapid transport for passenger transport
5. Promote non-motorized transport modes
6. Introduce taxes and other instruments to promote public transport

7. Introduce inland water transport modes
8. Modernizing and upgrading of suburban railway
9. Promote electric mobility and hybrid vehicles
10. Improve vehicle fleet efficiency
11. Road infrastructure development
12. Reduce GHG emissions from the marine sector
13. Generic enabling activities

While a more systematic project management and development process must be developed at ministerial and its sub-levels, it is envisaged that the already identified projects would yield significant contributions in emission reduction. The projects that can be implemented within the existing infrastructure & operational capacity will be prioritized for short-term implementation and projects such as LRT and Railway Projects which require large capital investments are to be identified as long-term projects.

The Low Carbon Development Strategy published by the Climate Change Secretariat under the Ministry of Environment outlines some of the strategies that can be implemented to reduce the emissions for the period 2021-2030 which are based on the National Determined Contribution (NDC) report published for the same period.

Sri Lanka Climate Prosperity Plan 2022 (V20, 2022), which has been endorsed by the President of Sri Lanka also outlines similar initiatives for achieving carbon reduction with a special focus on sustainable transportation. It specifies several targets with a time frame up to the year 2040 to achieve these goals. However, majority of these targets are focused only on electrification and promotion of non-motorized travel, as shown in Table 1.1.

Table 1.1 : Targets for Transport Sector in Sri Lanka Climate Prosperity Plan

Target		Year
Electric Mobility	Promotion of electric mobility and hybrid vehicles	2025
	50% of new road vehicles are electric or hybrid.	2030
	90-100% of new road vehicles are electric or hybrid.	2035
	50% of public transportation, including suburban railway, is electrified including through retrofitting.	2030
	100% of public transportation, including suburban railway, is electrified including through retrofitting.	2035
Non-Motorized Travel (NMT)	5km of bike lanes integrated into relevant roads in 10 key urban locations	2025
	50% of relevant roads include bike lane	2030
	90-100% of relevant roads include bike lane	2035
	Promotion of non-motorized transportation in key urban centers	2025
	Share of non-motorized transportation increases to 20% of all road trips	2030
	Share of non-motorized transportation increases to 30% of all road trips	2035

The estimated financing requirements for the proposed initiatives is US $ 2 billion over a 20 - year period. (V20, 2022)

1.4.3 Industry Sector

Following policies and related strategic declarations are in support of industry sector IPPU Net zero achievement either directly or indirectly.

- National policy on industry development (NaPID) and action plan (unpublished and in development / draft stage)
- National environmental policy (NEP) 2022
- National environmental action plan (NEAP) 2022 – 2030
- Draft national policy and strategy on sustainable development (2020)
- National policy on sustainable consumption and production (2019)
- National climate change policy (2014)
- National action plan for "Haritha Lanka" program (2009)
- National Policy and Strategy for Cleaner Production (2005)

In the newly developed NEP and NEAP documents, Industry sector has been selected as one of the main focus areas ("Air, Biodiversity, Climate, Coastal and Marine, Land, Waste, Water, Cities and Industry are the main focus areas reflected", specifically identifying the cement industry process emissions as "activity 3.3.6 - Reduce industrial process GHG in Clinker production in cement industry to reduce 180,034 tCO_2/year is proposed").

Similarly, the NaPID and industry development action plan as well as the NDCs proposes to address the climate change mitigation activities.

Though the above policies and guidelines are well developed, due to the lack of national apex / umbrella policy, proper coordination between policies is a major gap in the country context. Although Climate change, biodiversity loss and plastic pollution are recognized as the three top global environmental issues, in Sri Lanka the priorities given to these issues in national development path is observed insufficient. In addition to the policy gaps, certain ad-hoc initiatives / programs taken at political level never support the relevant priority issues.

1.4.4 Waste Sector

The following National Policies, strategies, and action plans for Sri Lanka provide policy directions for the waste sector.

Existing policies & strategies related to the waste sector

1. National Environment Policy (2022)
2. National Policy and strategy on cleaner production for the health sector (2007)
3. National Strategy for Solid Waste Management (2008)
4. National Climate Change Policy of Sri Lanka (2014)
5. National Policy on Waste Management (2019)
6. National Policy on Sustainable Consumption & Production (SCP) for Sri Lanka (2019)

Action plans related to the waste sector

1. National Environmental Action Plan 2022-2030: Pathway to sustainable development
2. National Action Plan on Plastic Waste Management 2021–2030

The National Environmental Action Plan 2022-2030: Pathway to sustainable development has defined a list of actions related to the waste sector, which is identified as a priority sector to reduce GHG emissions in the path of low-carbon development, by implementing appropriate mitigation measures. One of the main objectives under this Policy Thematic Area (PTA) is to create new partnerships and strengthen the existing ones for mobilization of resources to face global environmental challenges, especially for adapting to climate change impacts and mitigating GHG emissions (NEP, 2022).

In order to optimize the co-benefits of GHG emission reduction measures, including environmental quality improvement, better energy security, improved food security, decreased reliance on imported fossil fuels, and improved health benefits, alternatives in the Waste sector include, but are not limited to:

- Integrated waste transport solutions with low and zero-emission vehicles including non-motorized vehicles
- Integrated solutions of waste management
- Resource-Efficient Cleaner Production (RECP)

1.4.5 Agriculture Sector

The Ministry of Agriculture is one of the main agencies responsible for formulating and executing a coherent policy, which would support implementing a programme to achieve net zero status by 2050 in Sri Lanka.

In the ‘Republic of Sri Lanka Agricultural Policy and Program Review’ made by World Bank Group (1975) on Sri Lanka Agriculture, it has discussed the recent performance of the agricultural sector in Sri Lanka, recent policy actions and plans and identified areas for external financing in support of agricultural development. It is noted that Sri Lanka's agricultural policies aim to increase self-sufficiency in food production, diversify crop production, expand employment opportunities, and improve rural living conditions and social services.

The Government at that time instituted price support programs, productivity centers to improve extension, credit, input supply, and marketing services and legislation to control land use, tenancy, and ownership, and support and subsidy programs to assist the tree crop sub-sector. Additional measures recommended in the report include (i) reduction of the subsidy on fertilizer; (ii) expansion of extension programs; (iii) assessment of draft and mechanical power needs; (iv) improvements in land use; (v) improvement of farm credit programs; (vi) evaluation of taxation, levies, and subsidy systems; and (vii) provision of more foreign exchange.

The current National Agricultural Policy formulated by the Ministry of Agriculture was approved in 2021. Other current policy document that relates to Agriculture is the National Livestock Breeding Policy (DAPH, 2010)

National Agricultural Policy (2021)

The present National Agricultural Policy includes 12 goals to be achieved by 2030 (Ministry of Agriculture, 2021), aimed at doubling the resources-productivity while adhering to sustainable and ecofriendly agricultural practices and doubling the economic profitability of farmers and agri-producers, compared to 2020 values, and others that increase the yield and contribution of Agri-Food systems to the national economy, use of technology, high quality seed and planting materials, eco-friendly inputs, promoting participatory approach in decision making and building an agri-food system in Sri Lanka that is resilient to climatic and other disasters.

Even though climate mitigation actions are not specifically mentioned in the National Agricultural Policy (2021), achievement of these goals, particularly those promoting sustainable and eco-friendly practices and improved productivity would certainly contribute to mitigation of GHG emissions. The strategies and actions under these goals should be carefully developed, to lead to GHG emission reduction, without compromising or delaying the much-needed economic development, food security and climate resilience which far outweigh the need for climate mitigation actions in the context of the minimal contribution to the quantum of global emissions made by Sri Lanka.

The goals of the Paris Agreement cannot be met without transformative changes in the agriculture sector. Incorporating more ambitious, explicit, and directed actions in the agriculture sector in enhanced nationally determined contributions (NDCs) can help make this necessary transition (Ross et al, 2019). This needs going beyond 2030 targeting policies. The Ministry of Agriculture is one of the agencies responsible for formulating and executing a coherent policy, which would support implementing a programme to achieve net zero status by 2050 in Sri Lanka. The present agricultural policy has included following goals to achieve by 2030.

1. Double the resources-productivity (compared to 2020 estimates) by adhering to sustainable and eco-friendly agriculture practices
2. Double the economic profitability of farmers/agri-producers (compared to estimates of 2020)
3. Increase the contribution of the Agri-Food System up to 15% of the National Economy
4. Increase the adoption of technology developed locally along the agri-food value chain, by a minimum of 50% from the present status
5. Increase the high quality and high yielding seed and planting material production locally by 50% of the national requirement

6. Increase the eco - friendly inputs availability in crop production up to 100% of the requirement
7. Supply safe and quality food and feed in compliance with food and feed control regulations of the country
8. Establish a government-regulated food and feed control system supporting certification, standardization, and other logistics
9. Establish farmer/agri-producer groups with Agri-entrepreneurship capacity, coupled with efficient market systems
10. Establish a constituted role and mandatory participation of farmers/agri-producers in the process of decision-making
11. Build an agri-food system in Sri Lanka that is resilient to climatic and other disasters
12. Establish a system of transparent, accountable, responsible and participatory governance is established for decision making

The National Agriculture Policy (2021) - Policy statement 12

Promote adoption of appropriate adaptation and mitigation measures to increase climate resilience of the agriculture systems, where it has included as 12.3. Adhere to the actions related to agriculture identified in the National Adaptation Plan (NAP) for Climate Change and Nationally Determined Contributions (NDC). Thus, the National Agriculture Policy 2021 indicates the importance of strategies such as C net zero Concept to increase climate resilience of the agriculture systems.

National Livestock Breeding Policy (2010)

The Livestock sector has a National Livestock Breeding Policy (DAPH, 2010), where there is no mention made on strategies for reduction of enteric fermentation. However, the Department of Animal Production and Health (DAPH) at the First Stakeholder meeting had the view of the following strategies to reduce GHG emissions:

i. Improve dairy sector productivity by managing herd, herd health, feed and improving animal comfort and welfare;

ii. Improve productivity of Monogastrics by improving genetic, feed efficiency, animal health, comfort and welfare; and

iii. Adopt renewable energy for livestock applications

According to the Ministry of Livestock Development, the DAPH requires formulating a national livestock policy, but due to lack of adequate resources such as finance, manpower and technical knowhow, the task is getting delayed.

1.4.6 Forestry Sector

Sri Lanka submitted its initial NDCs in September 2016 as a country that ratified the Paris Agreement. After going through an intense readiness process in all the sectors in the NDCs, with up-to-date analysis, improved information and data, and an extensive stakeholder consultation process, the updated NDC was submitted in 2021 for the period 2021-2030. It represented a more ambitious, quantified, and robust assessment of the mitigation and adaptation measures for the next decade (2021-2030) informed by the forestry sector which is primarily a mitigation sector due to the trees being able to sequester atmospheric carbon dioxide in their food preparation process (photosynthesis),5 NDC actions were submitted with the primary objective of increasing the forest/tree cover in the country with the target of 32% of the country's land area by 2030.

The National Physical Planning Policy and Plan (2021-2050)

This Plan which is the updated version of the National Physical Planning Policy and Plan (2020-2030) states that all lands in the country cannot be put into economic use; some lands must be protected to fulfil certain objectives that will benefit the country and contribute to sustainable management. These lands include watershed areas, areas with rare ecosystems and ecosystems of exceptional diversity, areas with concentrations of economically important or potentially important species and threatened species, fragile areas that may be easily degraded, and important aesthetic, cultural, historical and recreational areas. The Policy, therefore, recommends that a protected area network be established that will integrate all the areas within the Country that need to be conserved. The areas included in the network will be divided into two categories depending on the level of protection afforded. They will comprise of areas that will be preserved strictly to protect biodiversity, soil, water, historical, cultural, religious and aesthetic values and scenic beauty. These will include all wildlife reserves, all conservation forests identified by the Forest Department, degraded forest areas that will be restored for ecological reasons, areas of archaeological and historical value where there are no development activities;, of natural beauty and natural features of exceptional value, environmentally and hydrological important lands in the hill country, areas where landslides are to be expected, un-utilized lands in areas of high rainfall intensity with slopes of over 60% and highly erodible soils and all natural and man-made water courses and water bodies, as well as their reservations and catchment areas.

The National Watershed Management Policy (2004)

This stresses the need of resolving degradation occurring in the upper watersheds of the country, which has manifested through denuded forest cover. The exposed slopes have become prone to landslides, and the soil profiles are truncated by erosion and poor in fertility, increasing fragmented and uneconomic land holdings worked on by the people, the silting of rivers and reservoirs, and the frequent and costly floods in the coastal plains.

The Land Use Policy (2007)

This aims to ensure suitable land use, food security, economic development and the maintenance of the productivity of the land in the country. It also promotes protection, conservation and sustainable use of the land resource and offers ideal framework that will best meet the needs of the present generation, while safeguarding the needs of the future generation. The Policy is very ambitious and aimed at directing land use in the direction of scientific land use. Mitigation of land degradation has been given high priority in the Policy and suggests enhancing peoples' participation in the sustainable use of land resources, rehabilitation of degraded lands, avoidance of type of land use that constrain sustainable development, preventing encroachment on state lands, creating awareness on scientific land use, implementing effective conservation measures for agricultural land use, rehabilitating marginal and uncultivated lands, protecting environmentally sensitive areas, protecting and conserving land above 1600 m elevation, conserving slopes exceeding 60% situated 1,600 m above mean sea level, using reforestation or agroforestry, and applying appropriate conversion measures in the landslide prone areas.

National Policy on Protection and Conservation of Water Sources, their Catchments and Reservations in Sri Lanka (2014)

This deals with the conservation, protection, rehabilitation, sustainable use and management of the watersheds, while maintaining their environmental characteristics with the involvement of people. The Government Extraordinary Gazette number 1894/3 of 2014/12/22 under the policy on conservation of Water Sources and Water Spouts of 2014 protects and conserves all water sources, their reservations, conservation areas and immediate catchment areas to ensure the existence of the water sources.

Forest Conservation Ordinance and the Fauna and Flora Protection Ordinance (2016)

Natural forests in Sri Lanka are owned, managed and protected by the Forest Department (FD) or the Department of Wildlife Conservation (DWC), and account for about 35% of the total land area of Sri Lanka (MoMD&E, 2016). The FD and DWC are guided by two legal enactments, the **Forest Conservation Ordinance and the Fauna and Flora Protection Ordinance.** Under the Forest Conservation Ordinance of 2009, natural forests coming under the jurisdiction of the Forest Department are designated as Conservation Forests, Reserve Forests or Village Forests and the Ordinance has provision to protect these forests and their produce. The Fauna and Flora Protection Ordinance No 02 of 1937 and subsequent amendments provide for the protection of six categories of natural ecosystems under the jurisdiction of the Department of Wildlife: strict natural reserves, national parks, nature reserves, corridors, and sanctuaries.

Section 13 of the Mahaweli Authority of Sri Lanka Act No.23 of 1979 states that "Notwithstanding the provisions of any other law and without prejudice to the generality of the powers conferred on the Authority by this Act, the Authority shall in or in relation to any Special Area have the power to take such measures as may be necessary for watershed management and control of soil erosion."

Section 22 of the National Environment Act No. 47 of 1980 and subsequent amendments states that the CEA "in consultation with the Council shall, with the assistance of the Ministry charged with the subject of Soil Conservation, recommend soil conservation programmes including therein the identification and protection of critical watershed areas, encouragement of scientific farming techniques, physical and biological means of soil conservation, and short term and long-term research and technology for effective soil conservation".

The National Watershed Management Policy of 2004 provides measures that conserves, protects, rehabilitates, sustainably uses and manages the watersheds, while maintaining their environmental characteristics with the involvement of people. The Government Extraordinary Gazette number 1894/3 of 2014/12/22 under the policy on conservation of Water Sources and Water Spouts of 2014 protects and conserves all water sources, their reservations, conservation areas and immediate catchment areas to ensure the existence of the water sources.

SECTION 2: INTRODUCTION OF THE SECTORS AND THEIR CURRENT STATUS

2.1 Introduction to each sector

2.1.1 Energy Sector

Sri Lanka's primary energy supply was predominantly from biomass (65%) and petroleum (27%) in the early 1980s. Due to the changes in living standards, biomass requirement was gradually reduced, and petroleum requirement gradually increased. The total energy requirement of the country was 509.6 Petajoule in 2019, and the primary energy supply mainly consisted of 223.8 Petajoule of Petroleum, 169.0 Petajoule of biomass, and 58.7 Petajoule of Coal. Accordingly, 55.4% of total energy consumption is from imported fossil fuels (Petroleum + Coal), and the balance is from indigenous resources (SLSEA, 2019). Figure 2.1 shows the distribution of the energy supply in the year 2019, while Figure 2.2 shows the variation of the energy demand by energy sources over the period 1983 to 2019 and Fig 2.3 shows the variation of total energy demand by the various sectors over the same period, as reported by the SLSEA (SLSEA, 2019). Biomass comes in different forms such as fuel wood (unprocessed logs and processed chips), municipal waste, industrial waste, and agricultural waste.

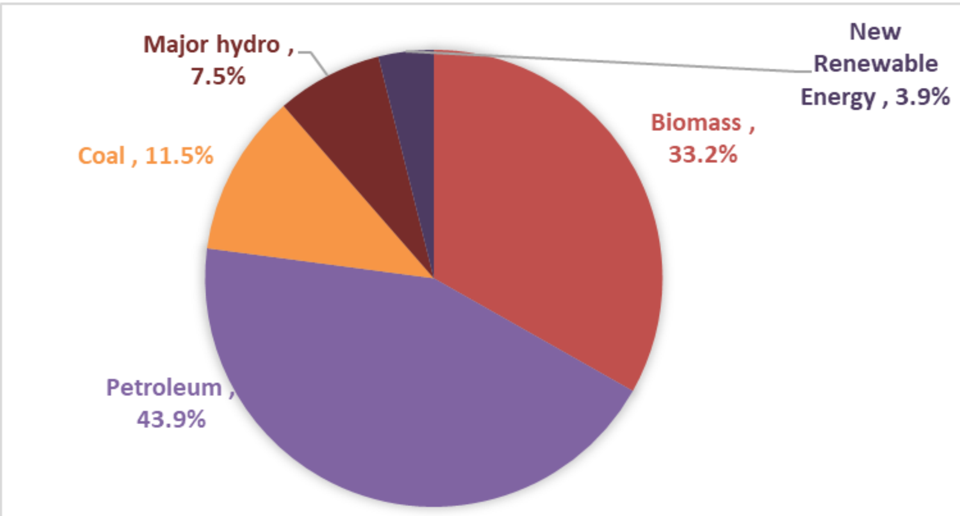


Figure 2.1 : Energy Supply in 2019 (SLSEA, 2019)

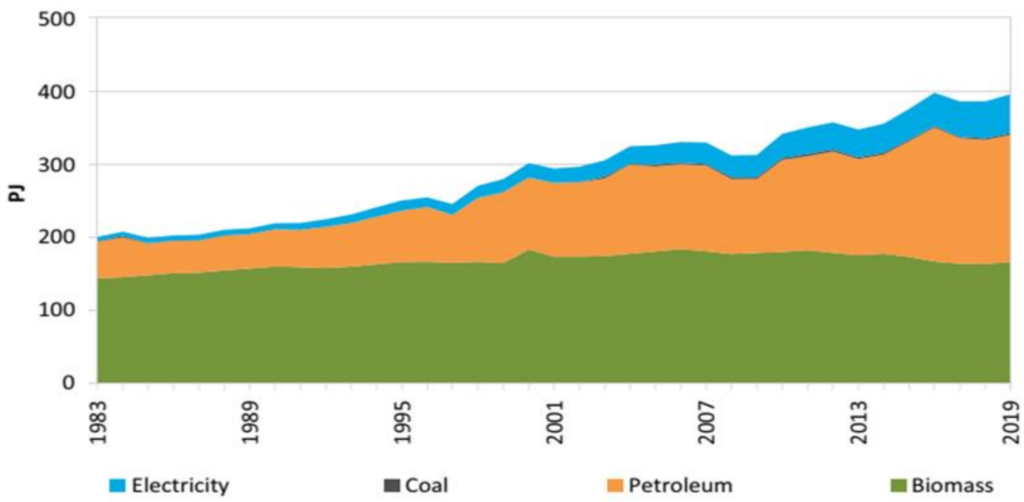


Figure 2.2 :Total Energy Demand by Energy Source

Considering the energy demand side, the main sectors of energy demand are Industry, Transport and Household, commercial and others. Figure 2.3 shows the growth of energy demand by the three sectors mentioned above.

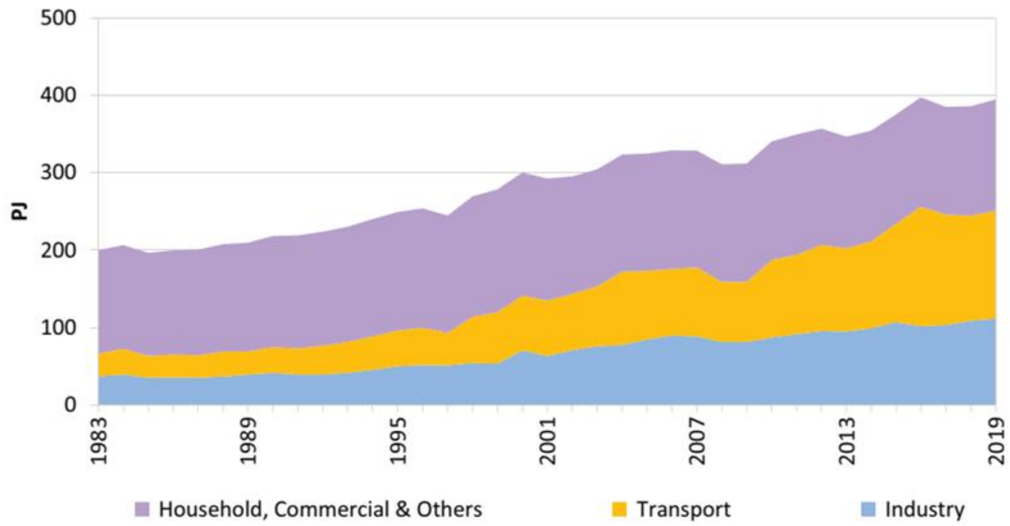


Figure 2.3 : Total Energy Demand by Sectors

The development of the net zero strategy for the energy sector has been done with relative ease due to the availability of several well-researched information sources and data bases. Some of these sources are the Ceylon Electricity Board (CEB), the Public Utilities Commission of Sri Lanka (PUCSL) and the Sri Lanka Sustainable Energy Authority (SLSEA). Useful energy data was also drawn from internationally active emission programs that have also been active in Sri Lanka, such as the Clean Development Mechanism (CDM). Further useful data was extracted from national plans such as the *National Energy Policy and Strategies of Sri Lanka 2019* and the Goal-7 of the Sustainable Development Goals (SDG's) of the United Nations and published in August 2019.

As the industrial (IPPU) and transport sectors are discussed in separate sections, only the contributions coming from the electricity sector, LPG, and Firewood are evaluated in detail in the energy sector.

The government's recent declaration of a 70% Renewable Energy 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. Quite independently, the Secretary to the Ministry of Power has committed to this goal that was national and international news. At present the Long-Term Generation Expansion Plan (LTGEP) considers achieving 70% RE by 2030 and maintaining 70% RE beyond 2030. Therefore, a further increase of RE component up to 100% by 2050 is not out of place.

Energy conservation through Demand Side Management (DSM) is also considered one of the potential areas of reducing electricity demand and thus reducing the emissions in the sector. Programs such as phasing out the use of incandescent electric lamps and introducing energy efficient equipment are expected to save 2,603 GWh and 5,189 GWh energy respectively, and thus 1,848 Gg and 3,684 Gg CO_2 emission reduction respectively, by 2030 (SLSEA).

It is targeted that a GHG reduction of 25% with 5% unconditionally and 20% conditionally in the electricity sector could be achieved, equivalent to an estimated mitigation level of 9,819,000 tonnes unconditionally and 39,274,000 tonnes conditionally (total of 49,093,000 tonnes) of carbon dioxide equivalent during the period of 2021-2030. This compares to the BAU scenario of the Long-Term Generation Expansion Plan 2013-2032 of Ceylon Electricity Board published in October 2013.

2.1.2 <u>Transport Sector</u>

Transport of Goods and Passengers including Warehousing is one of the major sub sectors that come under services in the Sri Lankan economy which contributed to 23 % of GDP in 2019.

Road density of 1.76 km/km^2 of Sri Lanka is one of the highest in the region with similar economic level. Road transport has become the dominant mode of transport resulting in 94% of passenger transportations and 98% of freight transportation which are moved by roads. Total road network in the country is about 115,000 km, which includes 12,496 km National highways (A & B class roads), 272 km of Expressways which are administered by the Road Development Authority and 18,617 km of Provincial roads managed by the respective Provincial Road Development Authorities. There are about 65,000 km of local authority roads in both the urban and rural sectors. The remaining roads estimated to total 20,000 km are owned or controlled by irrigation and wildlife authorities or other government agencies (NTC, 2021).

The present active vehicle fleet of Sri Lanka is around 6.7 million, of which 54% are motorcycles, 16% are three-wheelers (motor tricycles), 11% motor cars, and 1% buses (MoE, 2021). Vehicle population growth has been substantial over the last decade up to the year 2020. For example, between 2015 and 2019 alone, more than 1.6 million motorcycles have been added to the fleet, which has been the most significant factor for the observed vehicle growth in Sri Lanka. However, with the import restriction in progress, new vehicle registrations are very low. More than 30% of the operated motor vehicles are in the Western Province. Figure 2.4 shows the growth of vehicle numbers per 1000 inhabitants and as a percentage in Asian countries, over the period 2011 – 2018.

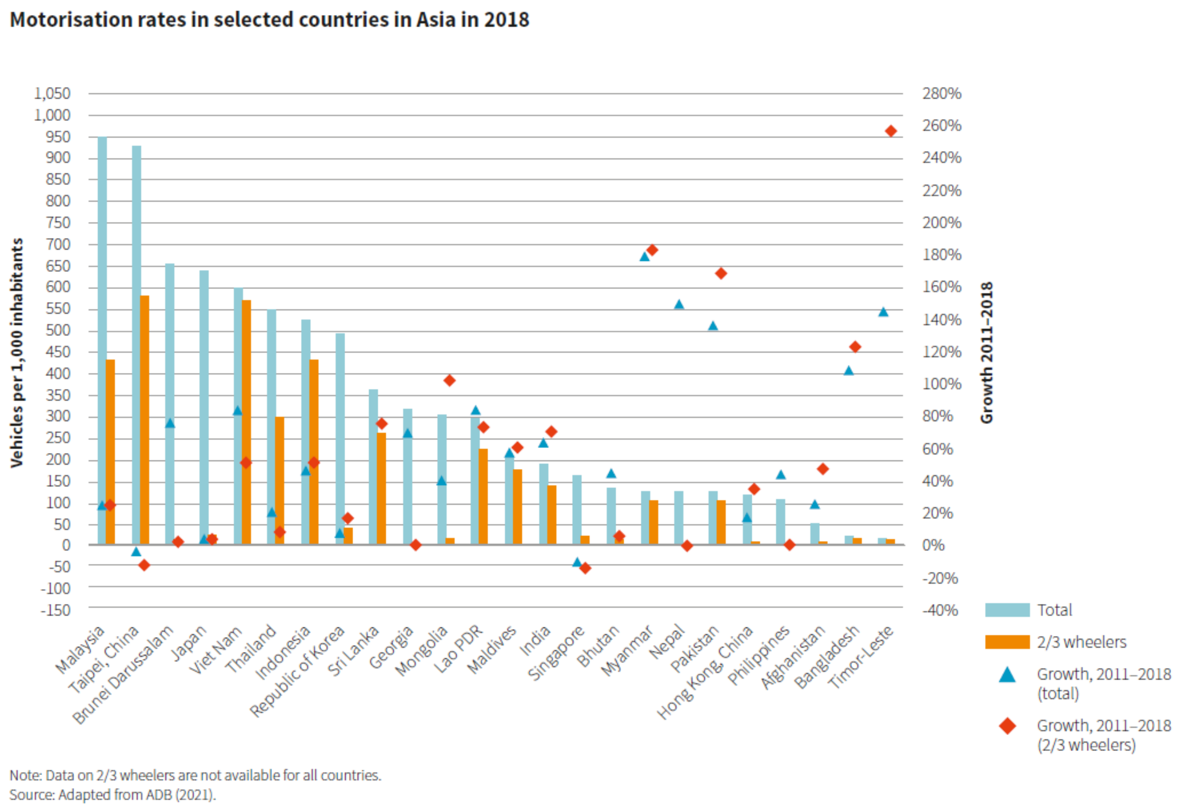


Figure 2.4 : The growth of vehicle numbers per 1000 inhabitants and as a percentage over the period 2011 – 2018 in Asian countries

Source: *Council for Decarbonizing Transport in Asia (2022).*

Sri Lanka Transport Board operates around 7100 buses, which ran approximately 430 million vehicle kilometers per annum and 14.3 billion passenger km, in 2019. A steady decline of around 4% p.a has been observed in the ridership of SLTB buses. Private bus operational fleet was around 19,980 in the year 2019, corresponding to 1085 million vehicle km and 54.2 billion passenger kilometers per year.

The rail network is 1619 km, which operated around 12.5 million train km in 2019 and 7.3 billion passenger kilometers; around 0.5 million goods train km were operated as well.

The modal share based on passenger km is around 37% for buses, 3% for railway and rest for private vehicles.

The active vehicle fleet in SL is shown in Figure 2.5, and it can be seen that the majority are motorcycles.

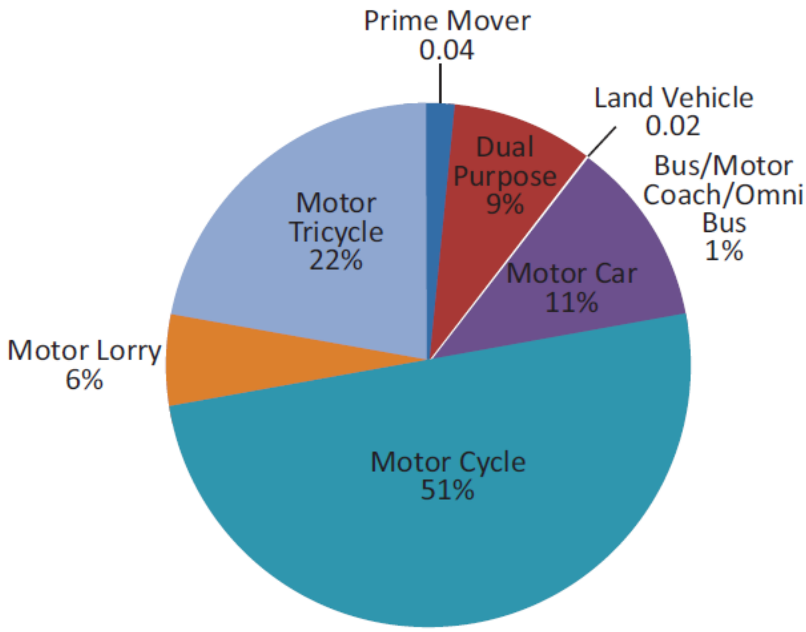


Figure 2.5 : Active vehicle fleet

Figure 2.6 below depicts the composition of the road vehicles, and the majority of the vehicles are being used for private transportation and public transport as a percentage has gone below the freight transport.

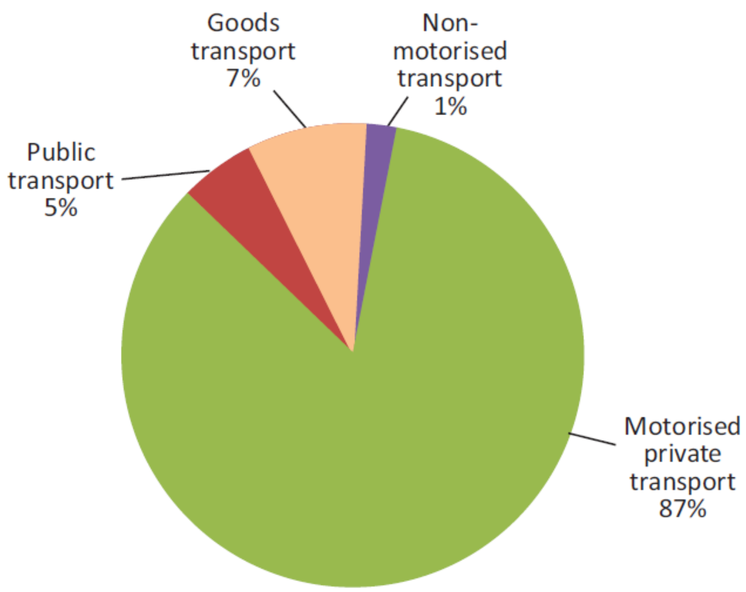


Figure 2.6 : Composition of the Road vehicles

Transport sector accounts for 21% of total emissions, and road transport accounts for three-quarters of transport emissions, road transport accounts for 15% of total CO_2 emissions. 128 kilotonnes of oil equivalent (ktoe)/person in 2016, which is an increase from 91 ktoe/person in 2000. Out of all fossil fuels used in the country, 39% was used for transport in 2016.

Although no major effort has been made to control emission levels, Sri Lanka's emission levels are comparable with Asian region countries considering the GDP and the population, as shown in Figure 2.7 and Figure 2.8. This also reflects the similar issues prevailing in other Asian countries.

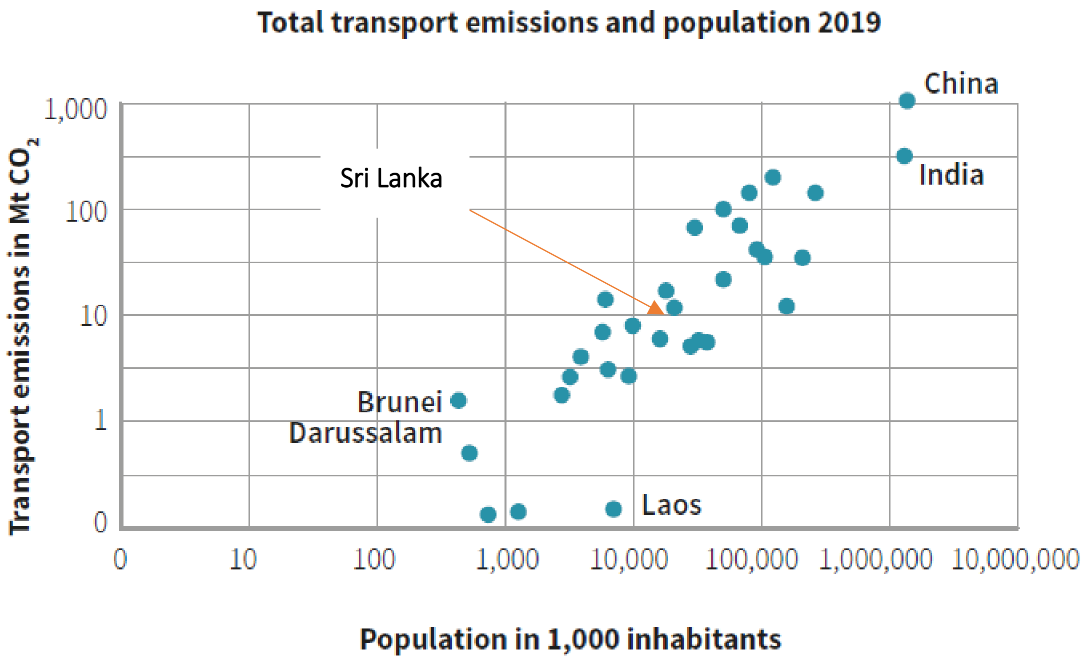


Figure 2.7 : Total Transport Emissions and Population, 2019

Source: Council for Decarbonizing Transport in Asia (2022).

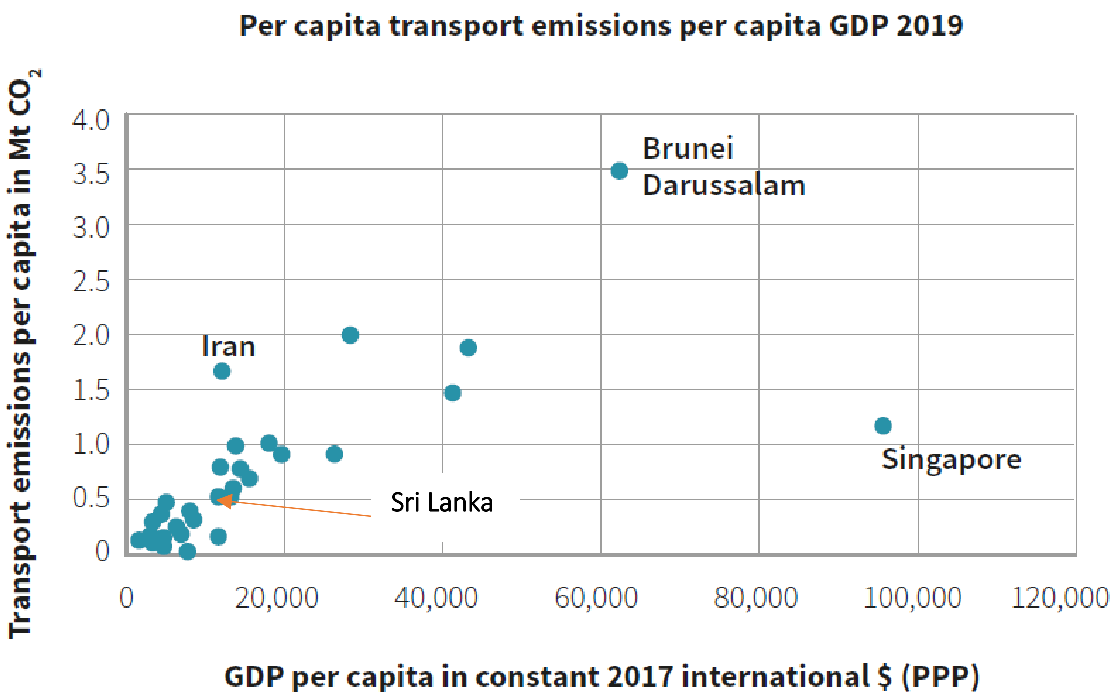


Figure 2.8 : Per capita Transport Emissions/ per capita GDP- 2019

Ref: Council for Decarbonizing Transport in Asia (2022). The Path to Zero: A Vision for Decarbonised Transport in Asia –Overcoming Blind Spots and Enabling Change"

2.1.3 Industry Sector

In the industry sectors, Chemical and physical processes that transform materials releases a significant amount of GHGs, such as CO_2, CH_4, and N_2O, industry sector being one of the major sources of emissions at the global scale. Additionally, apart from above gases HFCs and PFCs often are considered possible sources of emissions in the industrial processes and product use (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.

However, the national GHG emission picture is significantly different to the global picture, where, as shown in Figure 2.9, the industry sector only represents about 6% in the total emission account, including both industry energy use and process emissions. (TNC, 2021). Out of this 6%, industry sector energy-use related emissions accounts for about 5% and IPPU sector for balance 1%.

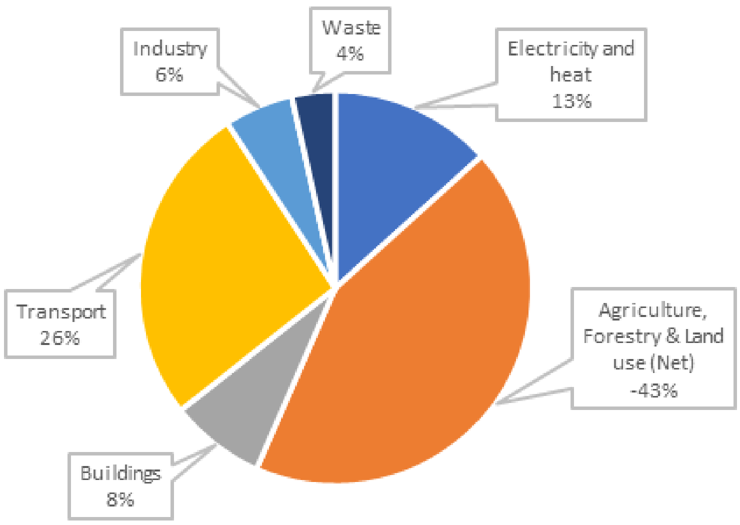


Figure 2.9 : National GHG Emission by economic sector

Source: 3rd National communication (2010 baseline data)

The emission mitigation and sequestration aspect of the industrial sector revolves around the existing industrial processes that have been somewhat taken up by the industry. Most of the current and past initiatives has come from private sector owners. However, again as in the transportation sector, no definitive or clear-cut long-term policies are observable. What is captured in terms of emissions management program for the industry are aspects met in other sectoral (emissions) abatement programs mooted mainly by the private sector owners to ensure sustaining the industry and work force, that is a very laudable effort indeed.

For example, the energy management activity in industry has a direct link to the emissions aspect of this study and provides a cross sectional view of measures and incentives available to the industry for energy savings. The call for fuel switching, power factor corrections, use of time-of-day tariffs all emanate from a study of the energy sector. Hence a clear-cut policy framework for the industrial sector has so far not been cast due to the very nature that many other aspects of sectoral interventions with other sectors being present. The following are some of the areas for emissions abatement and sequestration in the Sri Lankan industry.

- Cleaner production initiatives
- Energy efficiency improvements
- Industry feedstock quality management and circular economic options
- Utilizing green hydrogen and new renewable energy sources

2.1.4 Waste sector

The waste categories such as Municipal Solid waste (MSW), domestic wastewater, industrial wastewater chemical sludge, biological sludge, and sewage mainly emit Green House Gases (GHGs) into the environment, which caused he most important environmental hazards of global warming and the greenhouse effect that pose a threat on a global scale (Karl and Tubiello, 2021).

The waste sector contributes to producing greenhouse gases (GHGs) like carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) from solid and liquid waste categories as well as the waste management sector's vast array of activities.

GHG emission sources from different waste sector activities:

GHG emissions in the waste sector are generated from different treatment and disposal routes that can be categorized as emissions from (Vahk, 2020):

1. Municipal Solid Waste disposal (MSW management practices)
   - Open dumping (SWDS)
   - Landfilling
   - Biological treatment of solid waste (Composting)
   - Incineration and open burning of waste
2. Wastewater treatment and discharge (Industrial WW & domestic WW)
3. Sewage treatment and discharge
4. Chemical & Biological Sludge

Municipal Solid Waste includes garbage, refuse, or a variety of solid material of which the lifetime is over, or is discarded or rejected as useless or unwanted, from human and animal activities which originate from households, commercial establishments, and community actions that are collected by municipalities or other local authorities are considered as MSW. GHG emissions from the waste sector depend on the disposal processes used more or less, and the corresponding GHG emission intensity (GHG emissions per kg disposed of MSW) might reflect the city's waste management level (Liu *et al.*, 2021). MSW can be disposed of in several ways, including open burning, incineration, composting, or utilization as an input to biogas production. However, the majority of MSW ends up in landfills and open dumps where the anaerobic decomposition of organic material releases methane gas (CH_4) (Karl and Tubiello, 2021).

Intergovernmental Panel on Climate Change (IPCC)'s Inventory states that MSW is one of the main sources of anthropogenic CH_4 emissions, which is one of the most important greenhouse effect contributors (Zeng *et al.*, 2014). The GHG emissions from waste collection and landfill activities make a significant contribution; MSW is the fourth largest producer of global emissions of non-CO_2 GHGs that contribute towards global warming and climate change due to their emissions, and it approximately contributes 5.5–6.4% towards global methane (550 Tg) emissions annually (Maria, Góis and Leitão, 2020).

The general stages of MSWM such as collection, separation, treatment, transfer, and disposal all contribute to GHG emissions. There are further GHG emissions associated with waste receptacles, vehicles, and treatment facilities, as well as the transfer of residual waste materials from intermediate stations and treatment facilities to landfills (Skillicorn et al., 2013). GHG emissions in various stages of MSWM practices are indicated in **Figure 2.10.**

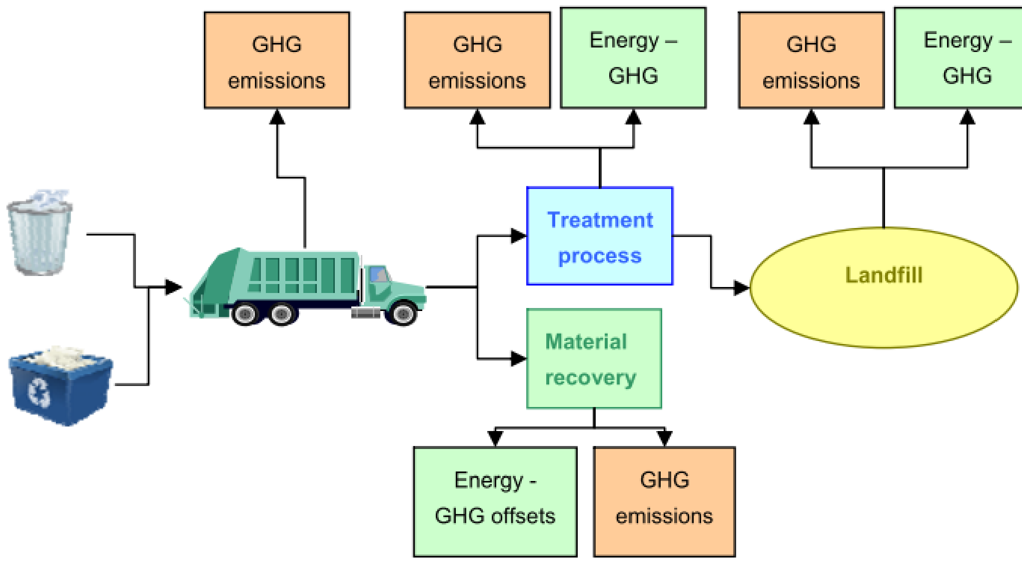


Figure 2.10 : Simplified schematic of the waste management system and GHG emissions (Skillicorn et al., 2013)

Open dumping is the most common practice of MSW disposal which creates numerous environmental and health impacts. Open dumping and landfilling produce CH_4.

Composting is a natural biological process, carried out under controlled aerobic conditions. In this process, various microorganisms, including bacteria and fungi break down organic matter into simpler substances. Compost piles have been found to release CO_2, N_2O, and CH_4.

Literature shows the impact of landfilling and composting on GHG emissions considering streamlined life cycle activities and the decomposition process which reveals that net greenhouse gas emissions for landfills tend to be higher than that for composting facilities (Lou and Nair, 2009).

Incineration and open burning of solid waste produces CO_2, CH_4, and N_2O. The incineration categories include solid and hazardous waste including pharmaceutical waste, waste oil, and industrial sludge. Open burning is the most common practices method of disposal of MSW in rural areas and sub-urban areas which emits 188,600 tonnes CO_2eq in 2022, where there are no proper waste management facilities available.

Municipal and industrial wastewater and their by-products sludge, produce GHG gases that induce global warming (Massoud, 2001). GHGs from wastewater treatment plants (WWTPs) include carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). GHGs from WWTPs can be divided into two categories. The direct emissions produce CO_2, N_2O, and CH_4 from wastewater sources and activities that promote fugitive gaseous emissions related to physical and biochemical processes. Indirect emissions include energy use associated with wastewater transportation, pumping, various treatment processes, effluent disposal, and residual management (Lisowski et al., 2011).

Sewage treatment plants are one of the significant sources of GHG emissions. Sewage treatment includes both industrial and domestic sewage treatment. During the sewage treatment, the anaerobic process produces CH_4 while nitrogen removal produces N_2O. Both CH_4 and N_2O are chemically stable and can stay in the atmosphere for a long period. The Global Warming Potential (GWP) for a 100-year scale of CH_4 and N_2O are 25 and 298 respectively (…).

CO_2 emissions from sewage are not considered in the IPCC 2006 records, however, and the reason posed is that these are of biogenic origin; but this aspect of exclusion should be questioned as national total emissions load is a function of this number as well, quite clearly, the growing number of sewage treatment plants inevitably leads to higher GHG emissions, posing a significant challenge to managing GHG emissions in the waste sector (Xing et al., 2012)

Chemical and biological sludge production during wastewater & sewage treatment in treatment plants has increased dramatically due to rapidly increasing population, industrialization, and urbanization, as well as to higher levels of wastewater treatment (Pilli *et al.*, 2016). Organic matter in sludge is converted to principal greenhouse gases (GHGs) such as CO_2, CH_4, and N_2O, depending on the environmental conditions during sludge treatment and disposal.

2.1.5 Agriculture Sector

Agricultural lands contribute to the greenhouse effect primarily through the emission and consumption of greenhouse gases (GHGs) such as methane, nitrous oxide, and carbon dioxide, as shown in Fig 2.11. In addition to that, green cover helps to reduce the greenhouse effect where, reflectivity or the land surface albedo (LSA) which is the ratio of the upwelling radiant energy relative to the down welling irradiance incident upon a surface of the land reduces by the green cover. In ecological systems, albedo can affect physical and physiological processes of ecosystems, such as energy balance and evapotranspiration by regulating the microclimate conditions of plant canopies and their absorption of solar radiation (Tian et al., 2014).

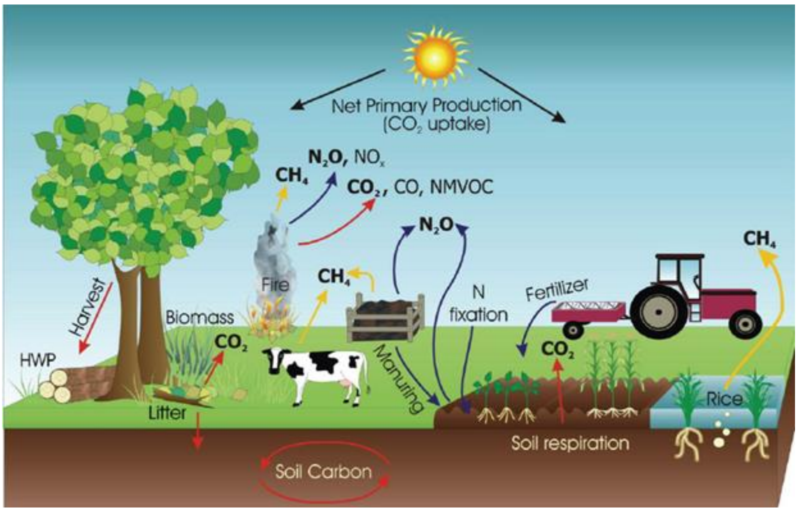


Figure 2.11 : Emission and consumption of greenhouse gases (GHGs) from Agriculture sector

Agricultural land covers approximately 2.6 million hectares or roughly 42% of Sri Lanka's total land area. The great 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 the statistics of Food and Agriculture Organization of United Nations, 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

(Punyawardena, 2007). These changing patterns of land use, coupled with the strict enforcement of anti-deforestation laws, have resulted in a decreasing rate of deforestation over the past decade (World Bank; CIAT. 2015).

Agriculture accounts for 25.1% (4.71 million tonnes CO_2e) of the country's total greenhouse gas (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 % (World Bank and CIAT, 2015).

It could be observed that with the trend of reducing GHG emissions, Sri Lanka can reduce to 61 % of the present level.

To reduce the GHG emissions from the agriculture sector, appropriate management practices must be introduced to minimize CO_2, CH_4 and NO_2 emissions. Further, *Land Surface Albedo* in agricultural lands could be minimized to lower the Surface Albedo and increase the green cover and increase the carbon sequestration and suitable alternative measures must be introduced to minimize CO_2 emissions from agricultural fields. The main emphasis in agricultural sector should be given to GHG emission reduction from rice fields, livestock, and cultivated area of organic soils in the order of importance.

In order to develop necessary mitigation measures carbon dioxide and methane emissions must be quantified for paddy cultivated areas.

Nitrous Oxide (N_2O) is liable for 6% of worldwide anthropogenic GHG emissions; 90% of those emissions are associated with agriculture. Increased N fertilizer usage and animal production are the most significant sources of the projected increase in N_2O. Agricultural soils are the key anthropogenic sources of N_2O and contribute around 60% of human-derived N_2O emissions (Marambe & Nissanka, 2019).

Urea is the major source of supply of nitrogen to crop production in Sri Lanka and urea is imported to Sri Lanka for agricultural use. Around 64% of the imported urea, with a nitrogen content of 46%, is used in paddy cultivation. The recovery of applied nitrogen to wetland paddy is around 20-40%. The agronomic efficiency of nitrogen (additional grain yield per kg N applied compared to without-N) is as low as 10 kg per kg of Nitrogen (Marambe & Nissanka, 2019).

Nitrogen utilization in the tea sector in 2018 includes 100.4 million kg of urea and 27.7 million kg of ammonium sulphate, totaling about 51.88 million kg of nitrogen. The total losses have been estimated at 40% of the applied nitrogen.

The position of Sri Lanka in the agriculture sector, measured based on the Sustainable Nitrogen Management Index (SNMI) in the Environmental Performance Index (EPI) by Pimonenko et al. (2018) is ranked low as 124 among the 180 countries indicating the significant improvement needed by the country in the future in achieving the Sustainable Development Goals (SDGs).

Livestock populations with ruminants emit methane due to the anaerobic digestive process in the forestomachs (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 nitrous oxide (N_2O) and CO_2 contribute 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 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 counting on various animal and feed-related factors. That would cause about 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 remain as minors.

2.1.6 Forestry Sector

Forests/trees are unique since only they have the ability to sequester atmospheric carbon dioxide in making their food through photosynthesis. According to the definition of the FAO, Forest is defined as: “land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. Therefore all natural forests, forest plantations and rubber plantations had been included into the definition of ‘Forests’. Trees Outside the Forests (TOF) are all the areas with trees which do not belong to the category of forests In the context of estimations in this report, the ecosystems which are quantifiable such as homegardens, coconut plantations, tea lands, trees in settlements, trees in urban environments including avenue plants) have been considered. Mangrove ecosystems belong to the category of forests in the forest classification but due to their enhanced ability of these ecosystems to sequester atmospheric carbon dioxide compared with the terrestrial tree based ecosystems, mangroves have been taken separately for quantification of carbon.

While healthy forests make a tremendously positive contribution to the balancing of GHG emissions caused by anthropogenic activities, deforestation and forest degradation pose a negative impact, by reducing the net biome production, and hence the carbon sequestration of the ecosystems. However, if the harvested wood is stored in wood products in use which do not degrade over many years, the carbon may be stored in them for long years before being released into the atmosphere, thus not contributing to the GHG emissions in the short term.

Figure 2.12 shows the processes in the carbon cycle with respect to the Forestry sector.

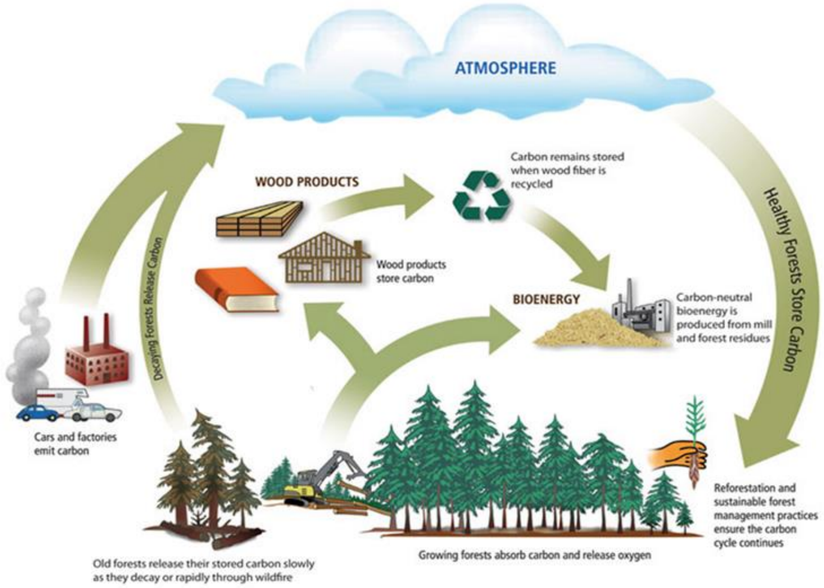


Figure 2.12 : GHG Emissions and Sequestrations from Forestry Sector

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 under Sri Lanka's three climatic zones; Wet, Dry, and Intermediate. Furthermore, forest-like home gardens and plantations of spices, rubber, timber, etc. 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 settlement, etc.). The main concerns for sustenance/protection of natural forests include deforestation, land degradation and soil erosion, illegal felling, wildlife poaching and mining, forest fires and degradation of coastal forests. Aside from the environmental implications, deforestation in Sri Lanka has caused landslides, soil degradation, flooding, loss of biodiversity and their habitats, pollution, etc. It is the primary threat to the survival of Sri Lanka's biodiversity.

Future Outlook & Carbon Sequestration Potential in Forestry Sector

A large number of legislative instruments, policies and strategies and programmes are in place to protect the forest cover. The Fauna and Flora Protection Ordinance (1993), Forest (Amendment) Act, No 65 of 2009, Forest Ordinance 1907 (No. 16 of 1907) as amended up to 2009, Sri Lanka Forestry Sector Master Plan 1995-2020 and its draft extension from 2021-2030National Environmental Act (1980) and its draft revision which is in the process of finalization, National Environmental Action Plan (2022) National Action Plan for combating land degradation in Sri Lanka 2015-2024, National Biodiversity Strategic Action Plan 2016-2022, Forest Conservation and Development Plan, Sustainable Land Management Programme, the National REDD+ Investment Framework and Action Plan are the more recent of these. The current policy framework of the Government provides broad guidelines and directions for sustainable forestry management. It envisions a "Net Carbon Zero Country" and the enhancement of the natural forest cover up to 30% by 2025; 32% by 2030 There is an emphasis on identifying and reforesting suitable lands, re-establishing and enhancing green cover, restoring barren and abandoned lands for agriculture and forestry, planting trees, establishing urban forests, green paths, green roofs and agroforestry systems, establishing parks in urban and semi-urban areas, developing urban vegetation by planting trees along expressways and in industrial premises -all of which can deliver emissions reduction. Forestry has enormous adaptation and disaster mitigation co-benefits. Forests protect catchments and ensure water availability downstream. Forests provide food and fuel for many rural communities and ensure biomass-based renewable energy availability. Nature-based solutions are proposed for many natural hazards, landslides, slope instability, flood, coastal erosion- in place of structures of cement and steel. Examples from Sri Lanka show that mangroves have protected communities from coastal degradation and forests on steep slopes have prevented landslides. Adapting traditional tree and food crops in agro-forestry systems can potentially support resilience (drought tolerance), improve food security (high nutrition fruits/food) and combat human-animal conflicts.

In the NDCs of the country submitted to the UNFCCC in 2021, five NDC actions have been committed in the Forestry Sector; Increase Forest cover of Sri Lanka up to 32% by 2030; Improve the quality of growing stock of natural forests and plantations; Strengthen catchment protection of major rivers and cascade systems, Improve and increase of Trees Outside Forests (TROF) and Generic enabling activities.

According to the updated NDC (2021-2030), 18,000 ha of new forests will be established by 2030 while the existing natural forests and forest plantations will be better protected. In the Net Zero Road Map and Strategic Plan, the Forest Department is hoping to reforest/afforest an additional 200,000 ha of land by 2050. Past Emission Trends in each sector (2010 - 2021)

2.2 Past 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. Tables 2.1 and 2.2 give the sector wise summary of national emissions for the year 2000 and 2010.

Table 2.1: Summary of national emissions for the year 2000

Source: Sri Lanka second national communication (MoE, 2011)

	CO_2 000' MT	CH_4 000' MT	N_2O 000' MT	Total CO_2e 000' MT
Energy	10,430.01	41.97	0.81	11,562.48
Industry process	492.40			492.40
Agriculture		185.14	2.65	4,709.44
LUCF	10.34	1.67		45.41
Waste		96.82		2,033.22
Total emissions	10,932.75	325.60	3.46	18,842.95

Table 2.2: Summary of national emissions for the year 2010
Reference Sri Lanka's third national communication (MoE,2021a)

Sector	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**

2.2.1 Energy Sector

In order to estimate the emissions related to the energy sector, emission factors recommended by the IPCC Guidelines are used. Here, CO_2 and SO_2 emission factors are calculated based on fuel characteristics, while NO_x emissions are based on plant technology.

Table 2.3 gives a list of emission factors for the different plant types and fuel types as per IPCC Guidelines, and Figure 2.13 shows the emission quantities from 2011 -2019 from the power plants, calculated using the emission factors.

Table 2.3: List of the emission factors (IPCC Guidelines-2006)

Plant Type	**Fuel Type**	**GCV**	**GCV**	**Sulphur Content**	**Emission Factors**			
		(kcal/kg)	(kJ/kg)	(%)	Particulate (mg/MJ)	CO_2 (g/MJ)	SO_2 (g/MJ)	NO_x (g/MJ)
Internal Combustion Engine	Fuel Oil	10,300	43,124	2-3.5	13.0	76.3	1.709	1.2
	Residual FO	10,300	43,124	2-3.5	13.0	76.3	1.709	1.2
	Auto Diesel	10,500	43,961	1.0	5.0	74.1	0.453	1.2
Gas Turbine	Auto Diesel	10,500	43,961	1.0	5.0	74.1	0.453	0.28
	Natural Gas	13,000	54,428	0	0.0	56.1	0.0	0.1
Combined Cycle	Auto Diesel	10,500	43,961	1.0	5.0	74.1	0.453	0.28
	Naphtha	10,880	45,552	0	0.0	73.3	0	0.28
	Natural Gas	13,000	54,428	0	0.0	56.1	0.0	0.1
Coal Steam	Coal	6,300	26,377	0.6	40.0	94.6	0.455	0.3
Dendro	Dendro*	3,224	13,498	0	255.10	0.0	0.0	0.2

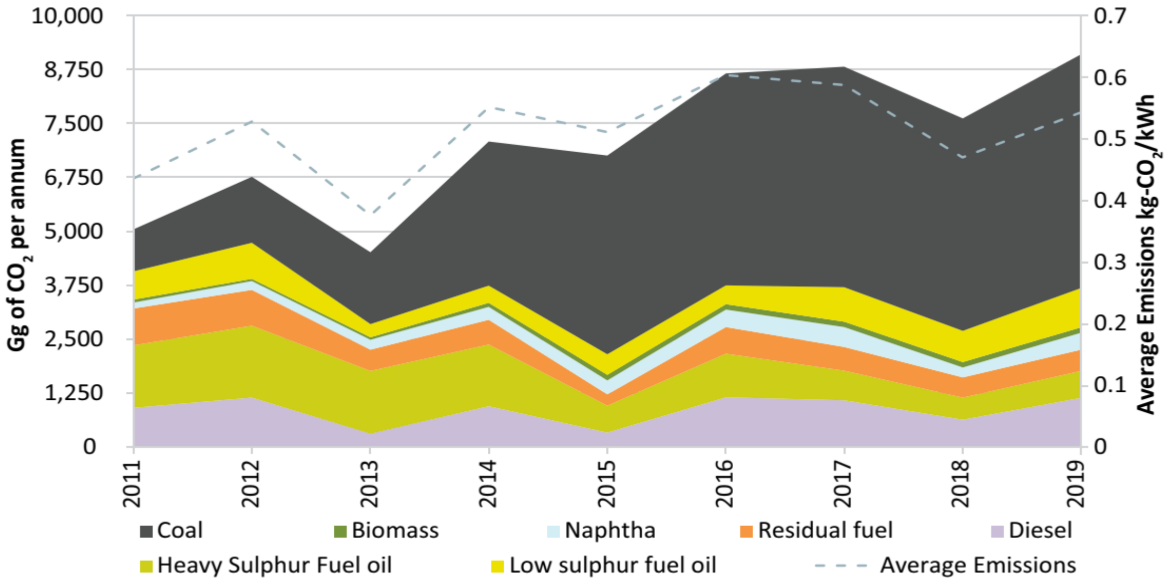


Figure 2.13 : Emissions from Power Plants (SLSEA, 2019)

For the electricity sector, the 'Average Emissions Factor (AEF)' is used to report the carbon footprint. The AEF is calculated by dividing the total emissions from the power sector by the total units of electricity used in the country in a given year. The AEF variation over the past is given in Figure 2.14 (SLSEA, 2019)

Figure 2.14 : Average CO_2 Emission Factor over the past decade

2.2.2 Transport Sector

Most vehicles in Sri Lanka are powered by fossil fuel, mainly auto diesel, and petrol. Some vehicles on roads today are powered by electricity, but the majority are powered by petroleum, and the entire rail transportation is powered using auto diesel. Transport fuel demand for the last few years is depicted in **Table 2.4.** (2020 to 2022 were not considered for the trend analysis due to the temporary economic slump.)

Table 2.4: Transport Fuel Demand

kt	2010	2015	2016	2017	2018	2019
Gasoline	616.5	1,009.0	1,463.1	1,276.8	1,358.7	1,421.5
Auto Diesel	1,433.8	1,815.1	1,902.6	1,605.3	1,568.4	1,606.5
Super Diesel	11.5	46.1	86.6	91.5	101.1	81.6

The estimated past emission trend for the Transport sector as given in the Updated NDC Report is shown in Figure 2.15. Sri Lanka's CO_2 emission in 2021 is 11 million tonnes, as estimated in the NDC report of the Ministry of Environment (MoE, 2021).

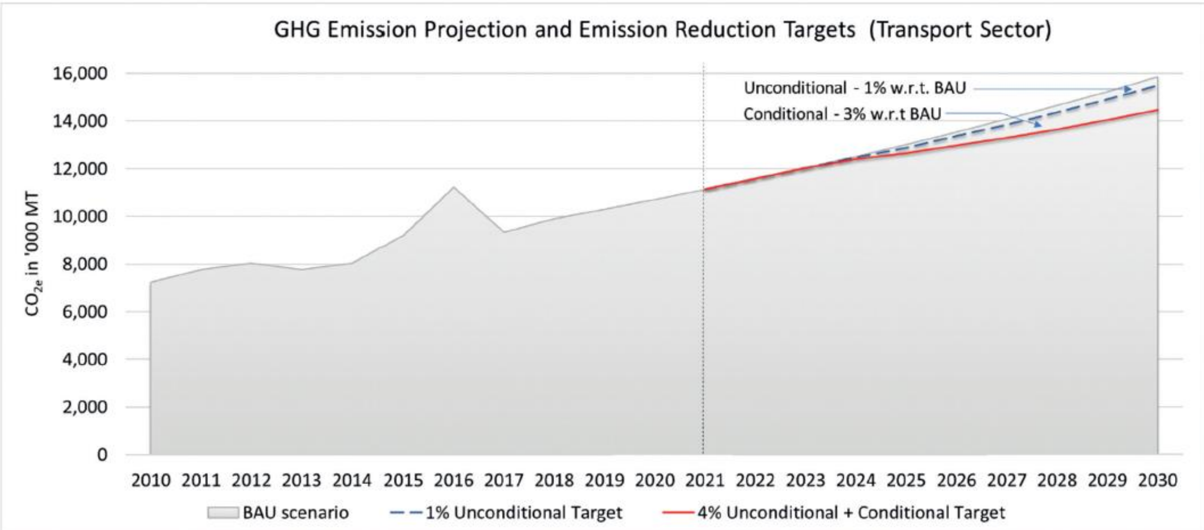


Figure 2.15 : GHG Emission Projection for Transport Sector (MoE, 2021)

Another estimate published by the Knoema.com database gives the CO_2 emissions from transport for Sri Lanka as nine million tonnes in 2021. It also states that CO_2 emissions from transport of Sri Lanka increased from 2 tonnes in 1972 to 9 tonnes in 2021, growing at an average annual rate of 3.81%. (*Sri Lanka CO2 Emissions From Transport, 1970-2022 - knoema.com*, 2022)

According to the World Bank database, CO_2 emission in 2014 from the transport sector was 6.2 million tons, at a growth rate of 5% p. a (the computed growth rate for total CO_2 emission for Sri Lanka from 2011-2016 is 4.8%), the estimated CO_2 emissions for 2021 is 8.8 million tonnes. (*CO2 Emissions From Transport (% of Total Fuel Combustion) | Data*, n.d.)

Calculation of CO_2 emission quantity based on the fuel consumption in the transport sector yields similar results to that of the World Bank estimates.

Table 2.5: Fuel Consumption in Transport Sector

Fuel type	lt(mn. tonnes)	CO_2 emission per liter(tonnes/lt)	CO_2 tonnes
Gasoline	1.4	0.0023	3300
Diesel	1.7	0.0027	4600
Total CO_2 emission in 2019			7900
Est. for 2021 at 5% p.a			8700

CO_2 emission based on Climate Analysis Indicators Tool (CAIT) estimates the CO_2 emission in 2019 in the transport sector to be 10.2 million tonnes (ourworldindata.org, n.d.), with the forecasted value-based linear regression of the previous 10-year data being 11.2 million tonnes. Since this is consistent with estimates used in the Sri Lanka NDC report published in 2021, the data set will be used for the BAU scenario, as shown in Figure 2.16.

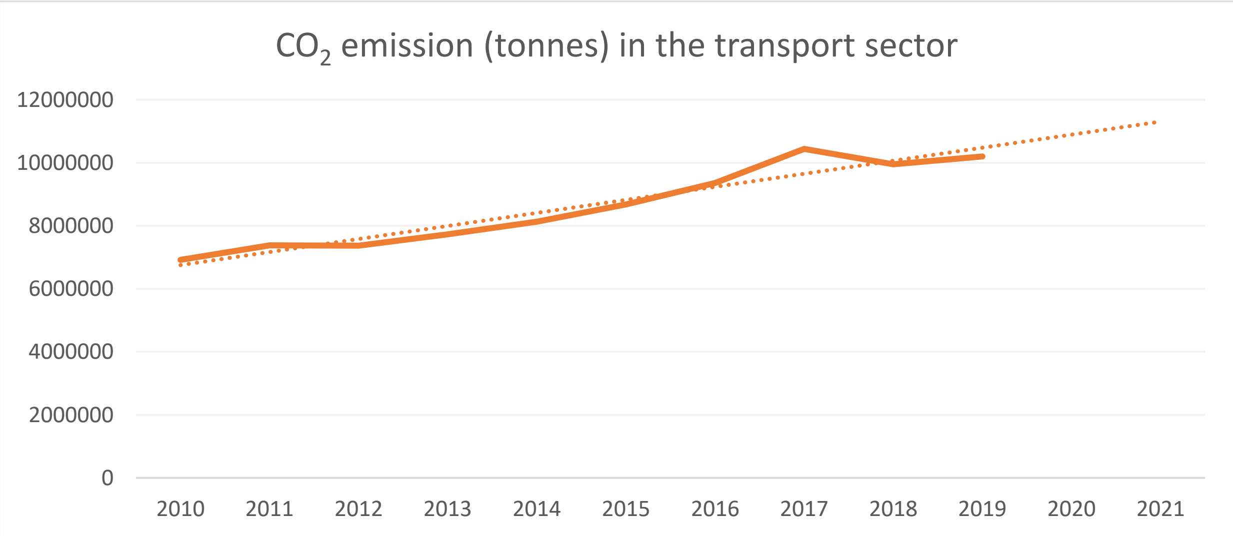


Figure 2.16 : CO_2 emission projection for the transport sector

However, the assumed growth rates in the NDC report would not have materialized under the economic conditions that prevailed in the country during the Covid Pandemic and the economic crisis during 2022. Therefore, suitable estimates based on BAU scenario modelling analysis will be used to derive 2022 values.

2.2.3 Industry Sector

Being a country of low-industrial activity, Sri Lanka does not have many relevant industrial processes (IPs). Accordingly, IP-related emissions are also relatively low. But fulfilling the UNFCCC reporting requirement, CO_2 emissions from the cement industry, lime industry, glass industry, ceramics industry, and Non-Methane Volatile Organic Compounds (NMVOCs) emissions from several other industries, manufacturing surface coatings, solvents, bread production, sugar production and liquor industry producing spirits have been identified for reporting of GHG emissions. The consumption of HFCs and their blends are also accounted for and reported under national GHG inventories. Such reported values for 1994, 2000, and 2010 respectively in the first, second, and third national communications are shown in T**able 2.6.**

Table 2.6: Industry sector related GHG emissions
Ref: MoE (2000, 2011 and 2021a)

Base year	1994	2000	2010
National communication	Initial	Second	Third
IPPU emission 000' $MTCO_2e$	300.55	492.40	447.97

According to **Tables 2.1 and 2.2 (**in section 2.2 of this report**),** industry energy use-related emissions are included in the energy sector. As industry mainly depends on the national grid to provide electricity, their emissions related to industry energy use are totally dependent on the national electricity generation-related emissions. Greening the national grid will have a direct impact on industry energy use emissions. Hence it is obvious that the emissions related to industry energy use totally depend on the low-carbon nature of the power supply.

But as the industry has a substantial potential to improve energy efficiency and renewable energy adoption through energy management strategies or demand management strategies, it is important to estimate the energy demand management-related emission reductions, to be fed into the data pertaining to the energy sector, under demand side management.

Only the Industry Process and Product Use related emissions need to be analyzed separately under the industry sector.

According to the IPCC inventory development guidelines (IPCC, 2006), IPPU (Industry Process and Product Use) is classified as one of the major categories of Greenhouse Gas (GHG) emissions. This covers GHG emissions occurring from industrial processes, from the use of greenhouse gases in products, and from non-energy uses of fossil fuel carbon.

On the other hand, during the NDC development process, the industry sector accounted the emissions from industry energy use related GHG emissions, and IPPU related emissions have not been accounted, due to the limited avenues, unavailability of large scale IPPU emitting industries (such as mineral industries, Chemical industries, primary metal production industries etc.) and poor reliability of data, and the quantity of GHG emissions from the IPPU sector is considered relatively low.

Industry sector total emissions, IPPU emissions and IE emissions for the period 2000 to 2010 are depicted in Figure 2.17

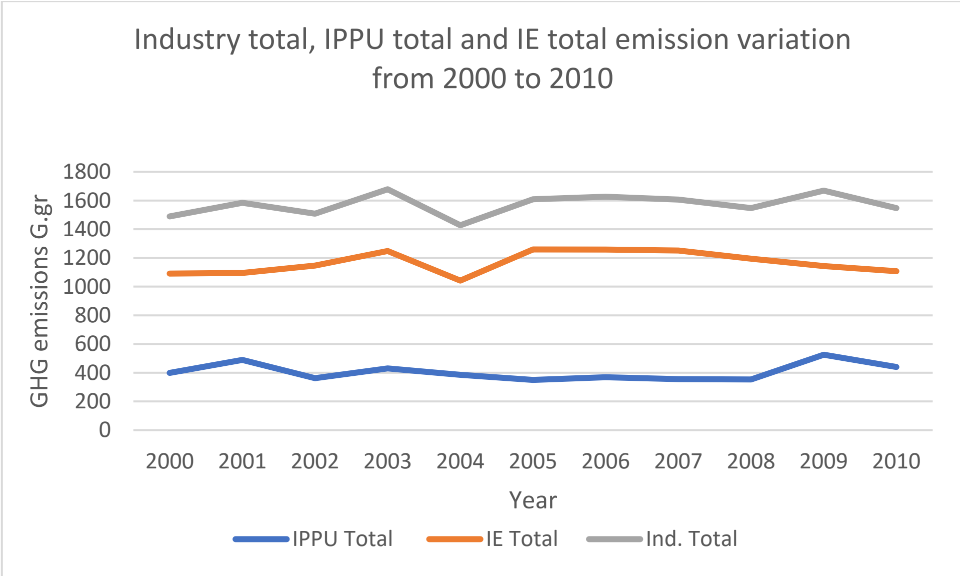


Figure 2.17 : Industry sector total emissions, IPPU emissions and IE emissions for the period 2000 to 2010

As the industry sector primary energy demand is well displayed under the national energy balance, during this national net zero emission strategy development process, industry energy use is directly addressed under the energy sector net zero emission strategy development process. Considering the complete accounting need, the IPPU related emissions are accounted under this strategy development process, though it is a relatively small quantity.

The estimated IPPU emissions reported under the third national communication (TNC) are taken into account as the reference or baseline values.

Accordingly, following national industry related major emission sources are considered:

- Cement industry (INSEE Cement manufacturing company)
- Glass manufacturing industry (Piramal Glass Company)
- Porcelain chinaware industry (Dankotuwa porcelain industry, Noritake Porcelain industry, Midaya Ceramic Industry, Art Decoration International Pvt Ltd, Royal Fernwood Porcelain Limited)
- Floor and wall tile industry (Lanka Tiles, Royal ceramics, Lanka Wall Tiles, Mack Tiles limited)
- Lime manufacturing industries

- Solvents used in national industrial applications
- National bread production in bakery industry

Although there are other minor emission categories relevant to GHG emissions, considering their insignificant values and unreliability of data (especially continuous data from 2000 to 2010) those are not accounted under IPPU emission projections.

The accounted emission (in 1000 tonnes) data for the period from 2000 to 2010 are given in Table 2.7 (Ref; TNC) and depicted in Figure 2.18.

Table 2.7: Industry sector IPPU emissions considered for calculation of past trends

Source: Sri Lanka Third National Communication, MoE (2021a)

Year	Cement	Lime	Glass	Ceramic	Solvent	Bread	Total
2000	196.71	123.6	4.45	2.53	69.83	1.32	398.44
2001	232.91	194.69	4.73	2.18	53.9	1.29	489.7
2002	243.92	71.57	4.28	2.8	37.84	1.3	361.71
2003	272.6	145.59	5.06	3.14	2.74	1.32	430.45
2004	264.05	111.73	5.5	2.88	0.02	1.34	385.52
2005	257.05	83.23	5.8	2.53	0.06	1.35	350.02
2006	250.55	107.9	5.73	3.06	0.06	1.37	368.67
2007	274.59	66.39	2.66	5.44	4.46	1.38	354.92
2008	270.71	64.17	10.21	3.59	2.75	1.39	352.82
2009	322.91	182.91	10.96	6.55	1	1.41	525.74
2010	331.32	85.1	11.5	7.67	2.73	1.42	439.74

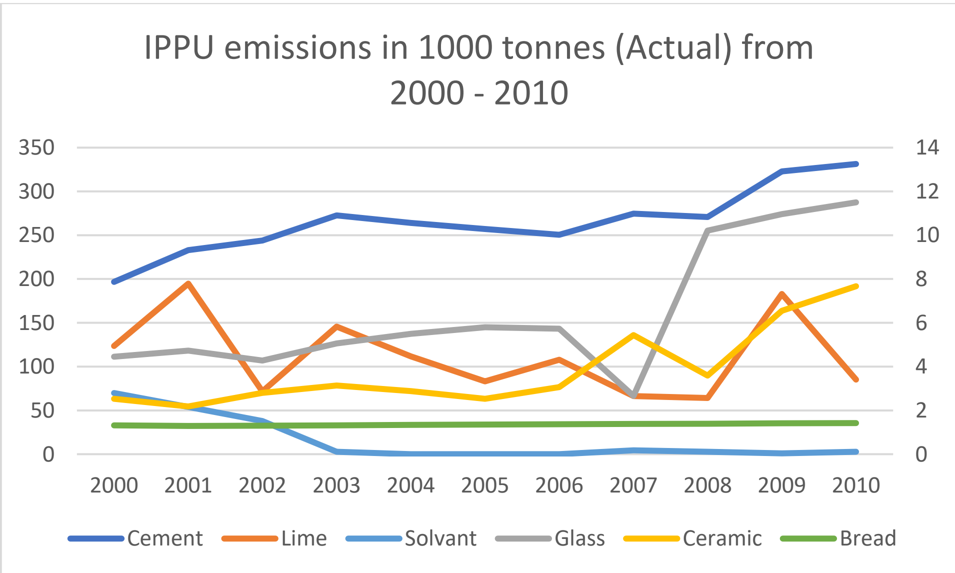


Figure 2.18: IPPU emissions in 1000 tonnes from 2000 -2010

Source: Sri Lanka Third National Communication, MoE (2022)

For the period of 2000 to 2010, IPPU emissions from different industry sub sectors are depicted in Figure 2.19.

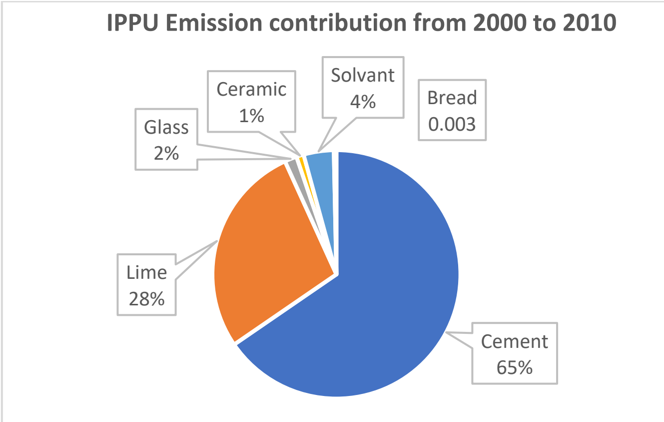


Figure 2.19 : IPPU Emission Contribution of main industrial sectors from 2000 - 2010

According to above analysis, major contributors to the IPPU emissions are Cement, Lime and solvent sectors.

Using the above trends, Annual IPPU emissions estimated for the period 2011 to 2022, as shown in Table 2.8 and Figure 2.20.

Table 2.8: Annual IPPU emissions estimated for the period 2011 to 2022

Year	GHG Emission (1000 tonnes)
2011	745.267
2012	908.6
2013	945.394
2014	1044.126
2015	1006.452
2016	1175.879
2017	1198.456
2018	1254.505
2019	1322.944
2020	1391.383
2021	1459.822
2022	1528.26

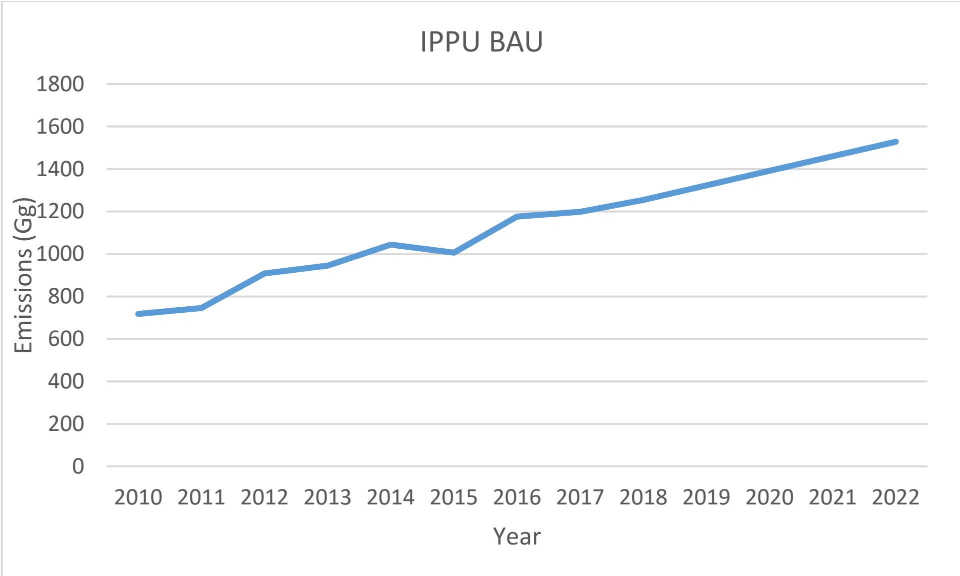


Figure 2.20 : Annual IPPU emissions estimated for the period 2011 to 2022

As IPPUs are not considered in the national NDC development, no NDC commitment based analysis / scenario development could be done for the industry sector.

2.2.4 Waste Sector

Sri Lanka generates approximately 9,000 tonnes of municipal solid waste (MSW) per day with a total volume of 3,500 tonnes (or 40%) produced in the Western Province and 5,500 tonnes (or 60%) produced from the other Provinces (MoE, 2021). Only about 55% in the Western Province and 25% in the other provinces of the generated waste is collected by local authorities. The rest of the waste remains uncollected.

Mainly the waste sector generates CO_2, CH_4, and N_2O gases from solid waste disposal, biological treatment of solid waste (composting), incineration and open burning of solid waste, wastewater treatment, and domestic discharge, as discussed in section 2.1.4 of this report. This prediction was carried out by referring to 2000 to 2010 data from the Third National Communication of Climate Change in Sri Lanka report (MoE, 2022).

The GHG emission trend has an increasing trend from 2010 to 2021 with a steady increase in each category where the emission from wastewater being the highest contributor and the least from composting which is happening at a small scale compared to the other category activities.

a) Emissions from solid waste disposal

The estimated methane emission in SWDSs during the period of 2010-2021 shows an increase from 228,000 CO_2e tonnes to 351,000 CO_2e tonnes of CH_4. Due to a lack of sufficient waste disposal facilities in the country between 2000 and 2010, while six unregulated SWDSs were in operation, waste management was not properly organized during that time.

The MSW generation during the 2010 to 2021 period showed increasing variation due to population growth, urbanization, and economic growth. Inadequate public commitment to waste management, a lack of proper waste segregation and adequate waste collection mechanisms covering the entire island, and practical challenges in the implementation of the 3R principles are some of the fundamental problems with the current waste management practices that also cause this growing trend.

during the 2010 to 2021 time period, the recorded largest disaster in Sri Lanka is the Meethotamulla dumpsite collapsing in 2017which is the biggest dumpsite in Sri Lanka that takes the majority of the garbage from the CMC and suburbs. by the disaster, A total of 1,765 individuals were impacted, 146 homes were destroyed, some infrastructure was damaged, 32 bodies were found in the destroyed region, and 8 more were unaccounted for (Jayathilake et al., 2020).

According to the National Solid Waste Management Center (NSWMC) records in 2020, there are 181 open dumpsites and 2 landfilling sites currently existing in the country.

b) Emissions from composting of solid waste

Composting is regarded as one of the most technically appropriate ways to manage MSW in Sri Lanka, especially given the simplicity of the technology and the nature of Sri Lanka's municipal garbage, which is still mostly organic (Gunaruwan and Gunasekara, 2016). According to the NSWMC data in 2019, there are 175 compost yards existing, with a total of 10011.7 tonnes/day capacity.

The estimated methane emission in composting during the period of 2010-2021 shows an increase from 66,779 CO_2e tonnes/yr to 74,768 CO_2e tonnes/yr of CH_4 as in figure 2-9 where the 2000 to 2010 data from Third National Communication of Climate Change in Sri Lanka (MoE, 2022) was used for the prediction up to 2021.

Composting turns a significant portion of the waste's Degradable Organic Carbon (DOC) into carbon dioxide in the aerobic process. In the compost pile's anaerobic areas, CH_4 is generated and discharged in small amounts and is frequently found at the bottom of heaps.

c) Emissions from open burning of solid waste

The most common practice of disposing of MSW in rural and suburban areas without access to suitable waste management facilities is open burning. Additionally, dry waste, including yard cutting, is openly burned in metropolitan areas too.

The estimated GHG emission in composting during the period of 2010-2021 shows an increase from 127,727 CO_2e tonnes/yr to 163,416 CO_2-eq tonnes/yr of CH_4 as in figure 2-9 where the 2000 to 2010 data from Third National Communication of Climate Change in Sri Lanka was used for the prediction up to 2021.

Most unregulated dumpsites practice open burning of solid waste, which has quite substantial air impacts in the surrounding. This open burning of waste can produce a variety of air pollutants, including NO_X, VOC, SO_X, particulates, CO, CO_2, and methane (APO, 2007). A crucial issue that needs to be addressed is the health risk, in addition to the poisoning of water resources and severe air pollution brought on by the open burning of solid waste.

d) Emissions from wastewater treatment and discharge

The domestic, industrial, and commercial sectors of the economy all contribute to the country's wastewater production. most Industries and industrial zones which produce a large capacity of wastewater located in urban areas had wastewater treatment plants. This wastewater treatment process generates GHG during the treatment process.

The estimated GHG emission in wastewater during the period of 2010-2021 shows an increase from 464,469 CO_2e tonnes/yr to 557,199 CO_2e tonnes/yr of CH_4 where the 2000 to 2010 data from Third National Communication of Climate Change in Sri Lanka was used for the prediction up to 2021. The emission from above activities a,b,c, and d are shown in Figure 2.21

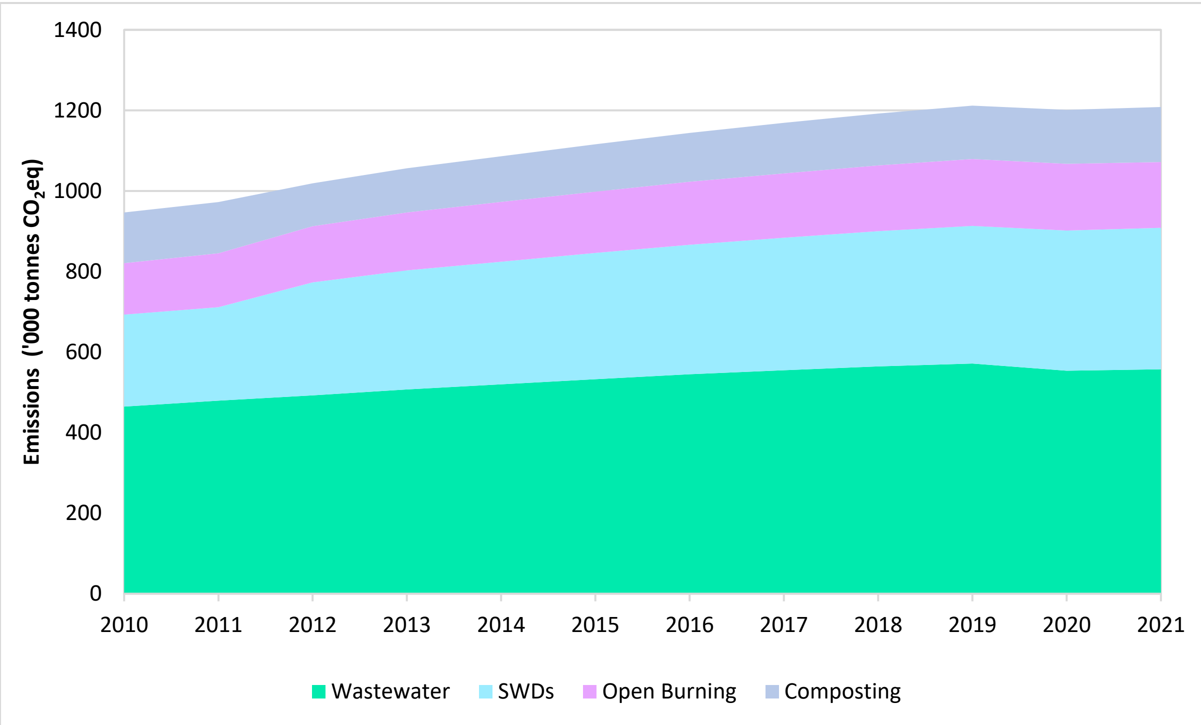


Figure 2.21 : GHG emission prediction from 2010 to 2021

2.2.5 Agriculture Sector

The current emission of main GHGs in agriculture sector as observed in 2019 is shown in **Table 2.9,** with a comparison to the same in 2008.

Table 2.9: Current emission of N_2O and CH_4 from agricultural lands (2019) compared to that in 2008

GHG	Unit	2008	2019
Nitrous Oxide (N_2O)	Mt CO_2eq	2230	2450
Methane (CH_4)	Mt CO_2eq	4500	4180
Carbon Dioxide (CO_2)	Mt CO_2eq	350	180

Source: Climate Watch. 2020. GHG Emissions. Washington, DC: World Resources Institute. *climatewatchdata.org/ghg-emissions*

2.2.5.1 Emission of Methane

Emission variation of CH_4 especially from enteric fermentation from 1990 to 2019 is given in **Figure 2.22.**

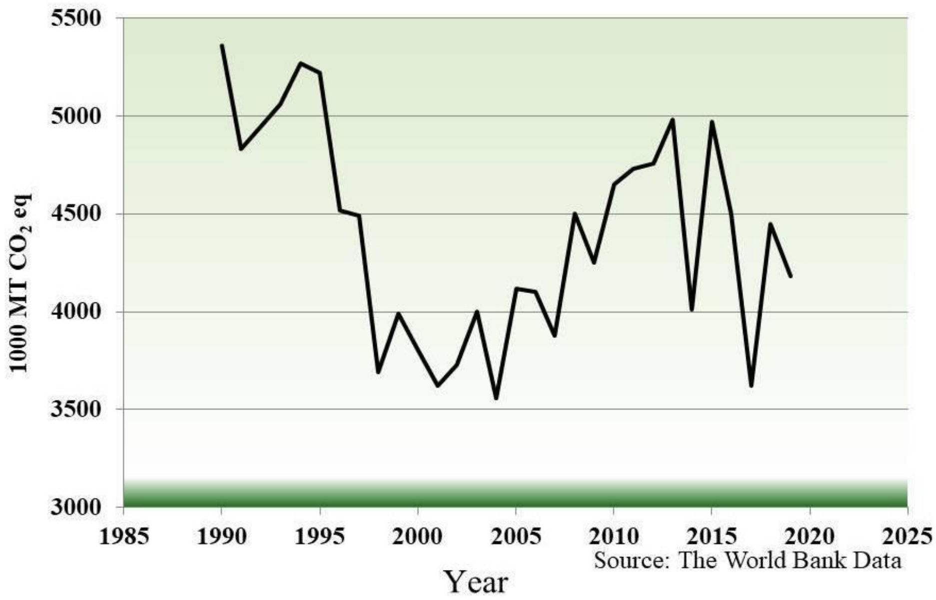


Figure 2.22 : Variation of CH_4 emission from agriculture (1990 – 2019)

Source: Climate Watch. 2020. GHG Emissions. Washington, DC: World Resources Institute. *climatewatchdata.org/ghg-emissions*

2.2.5.2 Emission of Nitrous Oxide

Though Sri Lanka's N_2O emissions fluctuated substantially in recent years, they tended to increase through the 2000 - 2019 period ending at 2,450 thousand tonnes of CO_2eq in 2019.

Synthetic fertilizers and organic after harvesting, and animal manure deposited during grazing are the most common sources that contribute to N_2O emission. N_2O emissions from cropping systems are strongly correlated to increased N fertilization. With the doubling of nitrogen use in South Asia since 1990, there is an excellent potential for enhanced N_2O emissions from the Asian region. The overuse of synthetic N fertilizer generates significant environmental threats. Nitrogen fertilizer, which is not taken by the crop, is either lost as Nitrogen gases, including the greenhouse nitrous oxide gas (N_2O). The emission variation of N_2O during the period from 2000 to 2020 is shown in Figure 2.23

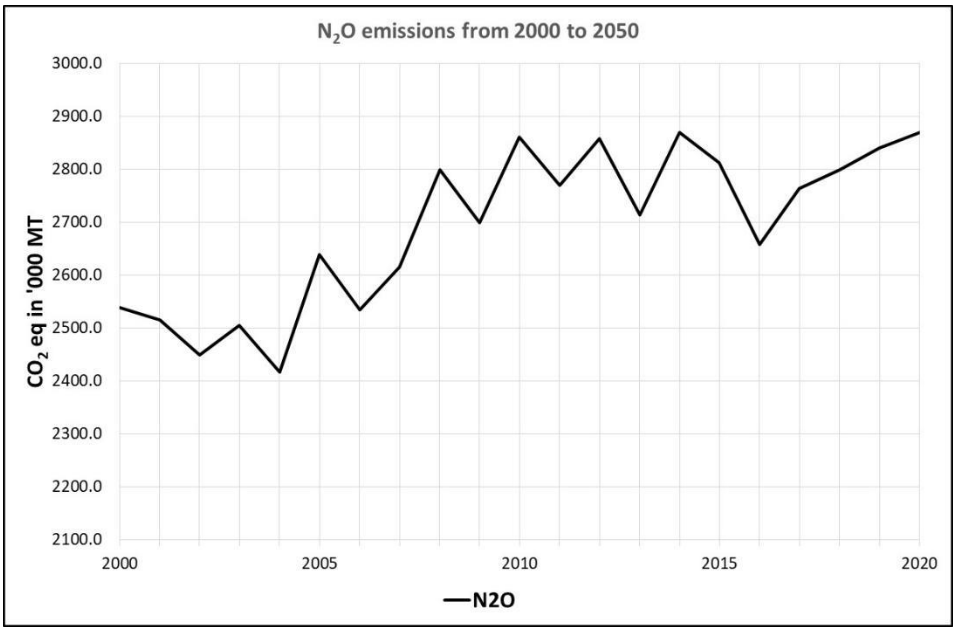


Figure 2.23 : Variation of N_2O emission from 2000 to 2020

Source: Baseline scenario developed for the study adopting NDC data

2.2.5.3 Emission of Carbon dioxide

Carbon dioxide is emitted from agricultural fields due to use of machinery, application of urea, dolomite and gypsum and tillage operations. The total carbon dioxide emissions in the agriculture sector over the period 2000 to 2020 is depicted in Figure 2.24. However, when comparing the total GHG emissions from CH_4, N_2O an CO_2 from agricultural fields in Sri Lanka, it can be seen that the emission of CO2 is negligible compared to other GHGs.

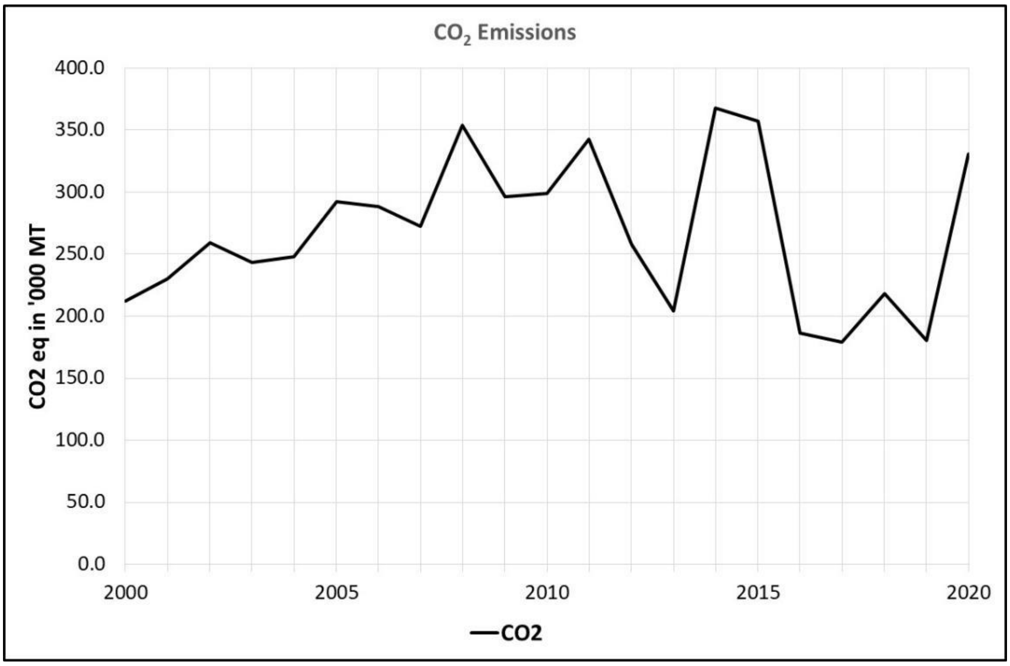


Figure 2.24 : Variation of CO_2 emission from 2000 to 2020

Source: Baseline scenario developed for the study adopting NDC data

2.2.5.4 Carbon sequestration from agriculture sector

Tea Plantations

Carbon sequestration by the plantation sector, which includes coconut, rubber and home gardens has been accounted for under the Forestry Sector. In addition, Tea plantations also have the potential for carbon sequestration, which does not fall under the categories of forests and Trees Outside Forests. However, the sequestration rates in tea plantations are very low (Table 2.10)

Table 2.10: Carbon sequestration from Tea plantations

Region	Kg of C ha^{-1} yr^{-1}
Low country	6,659
Mid country	3,497
Up country	2,344
Uva region	5,085

Source: Wijeratne et al. 2014

Paddy fields

The estimated global average of soil organic carbon stock of rice paddies is 108 tonnes/ha for the 0–100 cm layer. Average soil organic carbon stocks in rice paddies are lower than for mangroves, forests, and wetlands, but substantially higher than for grasslands and croplands, (Yalong Liu et al, 2021)

Results of a study carried out in Sri Lanka (Ratnayake et al 2017) showed that carbon fractions and nutrient availability among different cropping systems varied significantly from one another. Under all cropping systems a higher content of all C fractions was observed in the 0–15 cm layer. Highest dry matter return to soil (147 g/m2) in the rice-rice cropping system as paddy stubble accounted for highest amount of total organic carbon in soil. Change of cropping systems from rice-rice to other annual crops such as rice-tobacco and rice-onion reduced the soil C sequestration to a significant level after 10 years of cultivation. . However, crop rotation change from rice-rice to rice-soybean did not make much difference in the C level (rice-rice; 63.48 tonnes /ha and rice-soybean; 65.18 tonnes/ha) This indicates that C sequestration capacity is species specific and differences are mainly due to remaining crop residues and specific soil tillage practices used for upland crops.

2.2.6 Forestry Sector

The emissions from the forests including natural forests, forest plantations and rubber plantations which is taken as the ‘forests’ and the carbon sequestration of the forests is shown in Table 2.11 and Figure 2.25.

Table 2.11: Total Annual Carbon loss due to deforestation and Net Carbon sequestration due to remaining forests from 2010 to 2021

Year	Forest Cover with Forest Plantations and Rubber Plantations (ha)	Annual deforestation rate (ha)	Annual Carbon loss due to deforestation BAU (tonnes/yr) @ 150 tons/yr	A nnual Net Carbon Gain - BAU Scenario (tons/yr)
2010	2,107,202	6,953	1,042,950	3015851
2011	2,103,249	6,953	1,029,000	3050209
2012	2,099,576	6,953	1,029,000	3073207
2013	2,095,247	6,953	1,029,000	3090136
2014	2,088,294	6,953	1,029,000	3082794
2015	2,088,294	5,000	750,000	3365857
2016	2,078,822	5,000	750,000	3372116
2017	2,075,069	5,000	750,000	3378375
	2,070,312	5,000	750,000	3375343

Year	Forest Cover with Forest Plantations and Rubber Plantations (ha)	Annual deforestation rate (ha)	Annual Carbon loss due to deforestation BAU (tonnes/yr) @ 150 tons/yr	A nnual Net Carbon Gain - BAU Scenario (tons/yr)
2018				
2019	2,066,045	5,000	750,000	3376843
2020	2,063,437	5,000	750,000	3393689
2021	2,059,237	7,500	750,000	3395809

Source: Preparatory document of the Updated NDC (2021-2030)

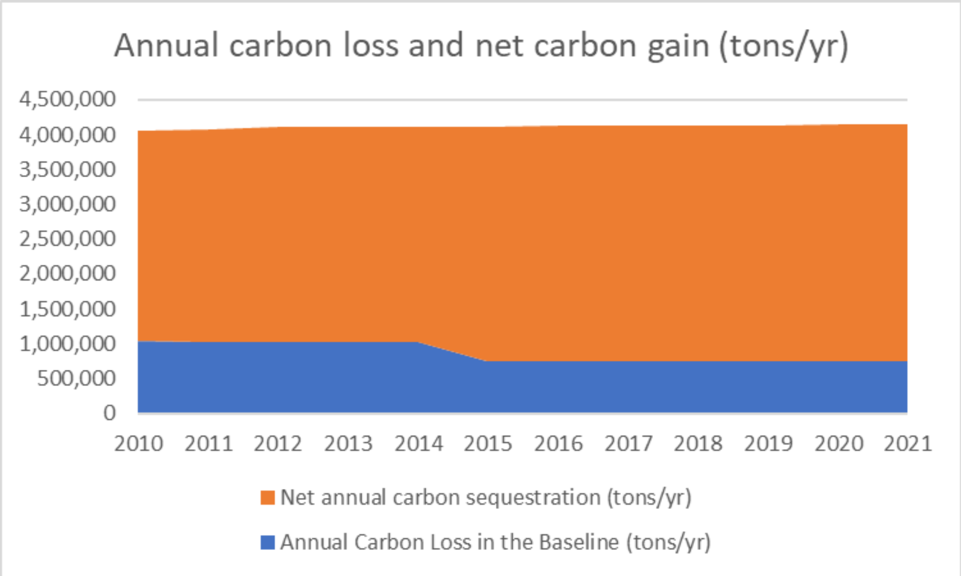


Figure 2.25 : Annual Carbon loss due to deforestation and Carbon sequestration due to remaining forests from 2010 to 2021

SECTION 3 : SCENARIO DEVELOPMENT AND PREDICTION OF EMISSIONS

3.1 Scenario Development and Prediction of Emissions 2025 – 2050

3.1.1 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 & technologies to identify existing capacities & quantify required resources. At least two scenarios are used as baseline scenario & net zero (Mitigation) scenario for each sector to quantify GHG emissions by 2050 with existing emission reduction approaches & plausible reductions by proposed technologies.

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 business-as-usual 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 system analysis.

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

GHG emission reduction: Quantified decrease in GHG emissions between a baseline scenario and the GHG project/ GHG mitigation scenario.

GHG removal enhancement: Quantified increase in GHG removals between a baseline scenario and the GHG project/ GHG mitigation scenario.

GHG project: Activity or activities that alter the conditions of a GHG baseline and which cause GHG emission reductions or GHG removal enhancements.

Baseline is a plausible and consistent description of how a system might evolve into the future in the absence of explicit new GHG mitigation policies. Depending on the selected mitigation scenario different baseline scenarios will require to differentiate GHG reduction or removal enhancement. Sector-wise GHG emission trends & drivers for activity data will be identified using history data. Regression (linear & multiple) models will be used to identify drivers and relationships between the driver & activity data. To reduce the uncertainty of baseline scenarios, multiple baselines are constructed to reflect sensitivity for different aspects, as shown in Figure 3.1.

Demographic trend, economic trends and Evolution of technologies & practices will be considered for identifying driving forces (drivers) for Activity data.

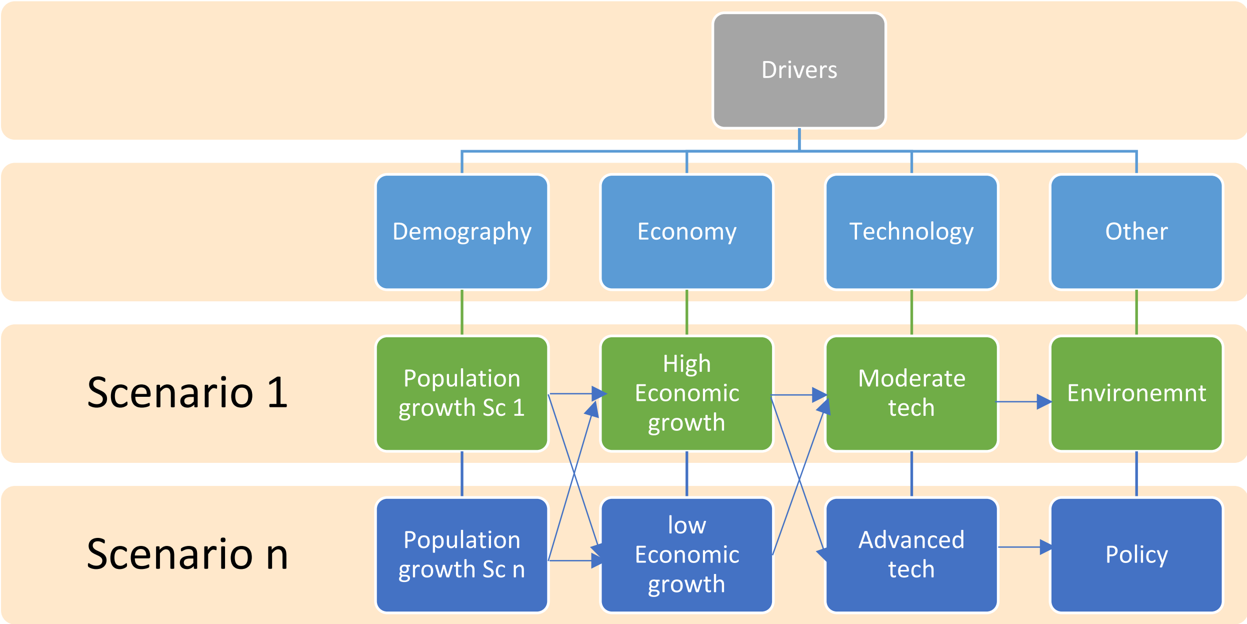


Figure 3.1 : Drivers for development of sector wise modeling of future scenarios

Theoretically, three approaches are used to define baselines:

1. **Economic efficiency case:** assumes perfect allocation of resources: mitigation will always imply economic losses. (High economic development Scenario)
2. **Business as usual case:** a continuation of current trends. (BAU)
3. **Most likely case:** markets and institutions are NOT assumed to behave perfectly. May imply the existence of "no regrets" mitigation options. (NDC Scenario)

In this study, the 'Most likely case', will be used as the baseline scenario.

Figure 3.2 illustrates the way that future emission predictions are developed using econometric prediction models for different future scenarios. The demand for sector activities would be increasing with the time, depending on the population growth and various other drivers identified for the development of the sector considered. Thus, the extension of the historical curve will follow a path which is not necessarily an extrapolation of the historical curve. Under the baseline scenario, the emissions will change with the time, based on the growth of the activity under the normal or most likely case. Under the mitigation scenarios, the emissions will depend on the timing of mitigation actions and the predicted reductions due to the actions in place. In the 'carbon net zero' scenario, the emission curve should take a drastic downward trend, while the GHG emission removal curve (sequestration or trapping) should take an upward trend.

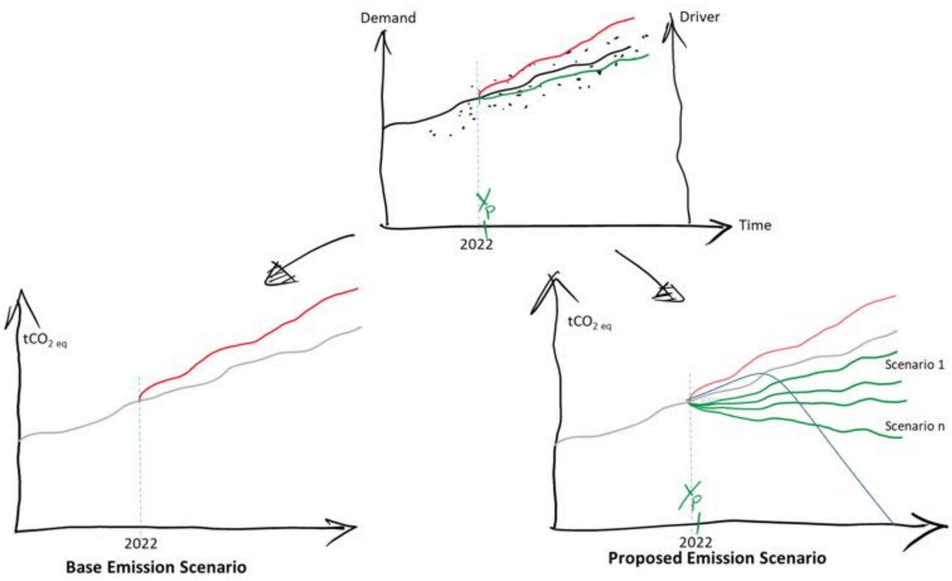


Figure 3.2 : The plausible future emissions calculated based on baseline scenario and scenarios considered with mitigation actions, using econometric modelling

Sector wise activity data, driver-related data & other specific data requirements depend on scope and mitigation activities selected for the analysis. 2000 – 2022 historical time series data (as available) will be used for developing history trends and identifying driving forces. Secondary data will serve the purpose.

$$GHG\ Emission\ = Activity\ Data\ \times Emission\ Factor\ \times GWP$$

Emission factors & GWP values are Based on historical time series data, driver/s can be identified for each activity data or for the sector using regression models. Future activity data will be forecasted using the function derived by the regression model.

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

Baseline (Business as Usual – BAU) Scenario Development:

The NDC Implementation Study being conducted concurrently with the present study has got results to show that the emissions during the period 2020 to 2022 follows a path close to the path followed by the emission levels with the implementation of the unconditional NDC actions in the sectors, rather than the BAU scenario taken in the NDC Report. (Figures 1:7.1 to 1:7.6 in the Interim Report of the NDC Implementation Study).

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, were taken as the Baseline scenario.

- For Population Predictions, the population data from the UN World Population Prospect 2022 (UN, 2022) as given in Figure 3.3

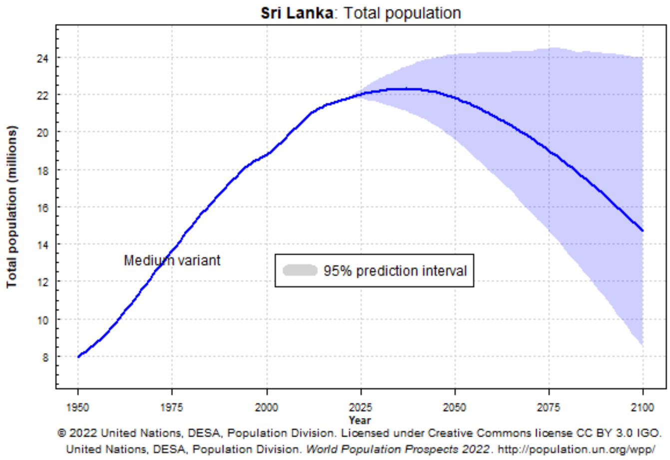


Figure 3.3 : Projected Population for Sri Lanka

- For GDP growth rate, the average values given on Page 46 of the Sri Lanka Climate Prosperity Plan (CPP) Preliminary report (V20, 2022), as shown in Table 3.1 were used:

Table 3.1: Real GDP growth rate comparison within each scenario

Scenario	2022-2030	2030-2040	2040-2050	2022-2050
BAU (Percent)	3.7	2.9	2.8	3.1
CPP (Percent)	4.4	4.3	3.9	4.2
CPP vs BAU	+21.6%	+48.1%	+37.3%	+35.9%

Thus, a Real GDP average growth rate of 3.1% was used for the Baseline scenario.

Mitigation Scenario - Net zero scenario: Actions and strategies to achieve net zero emissions by 2050

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 by the consultants, which went beyond the NDC actions, were to be implemented as proposed, in a timely manner. Therefore, the Mitigation Scenario was taken as the Net Zero Scenario.

For each sector, drivers for growth of the sector were identified using available history data using regression analysis, and econometric models are being used to predict the future demand and emissions in the sector activities, with the implementation of mitigation actions proposed for reduction of emissions and increase of carbon stocks (sequestration and carbon storing in biochar etc.).

Each sector considered several options/pathways of mitigation actions under this scenario.

According to the CPP Preliminary report (V20, 2022), the CPP scenario is defined as:

“In the CPP scenario, additional ambition for climate change mitigation was simulated on top of the NDC ambitions, ensuring that net zero emissions are reached in the year 2050. Furthermore, the CPP scenario also assumes the implementation of prosperity measures to achieve targets and objectives outlined in the official target document, such as for example adaptation measures for agriculture production and infrastructure (e.g. roads, buildings, power generation).”

This is the ‘Best case’ scenario, where the Carbon net-zero is achieved and the vulnerability to Climate Change is minimized.

A Real GDP average growth rate of 4.2% will be used for the Net Zero scenario as the average over the period.

Considering the many linkages among the sector actions and impacts, the Net Zero scenario were developed, with interactive sessions among the sector experts and social, gender and economic analysts who have a major role to play in selecting the optimum pathway/s for achieving net zero.

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 time, not later than 2050, while the most economically, socially and environmentally acceptable pathways will be identified for implementation.

3.2 Sector wise Prediction of Emissions for the Baseline Scenario

3.2.1 Energy Sector

For the power sector, CEB has developed the Long-Term Generation Expansion Plan (LTGEP) 2023-2042 which complies with the NDC commitment, with more than 25% reduction in GHG emissions for the period from 2023-2030, compared to the BAU scenario of LTGEP 2013-2032. The unconditional targets have been declared based on the financial and technical capability already available in the country. However, the conditional targets require an external financial and technical support to supplement the domestic capacity. It is forecasted that the electricity peak demand increases on average at 5.3%.

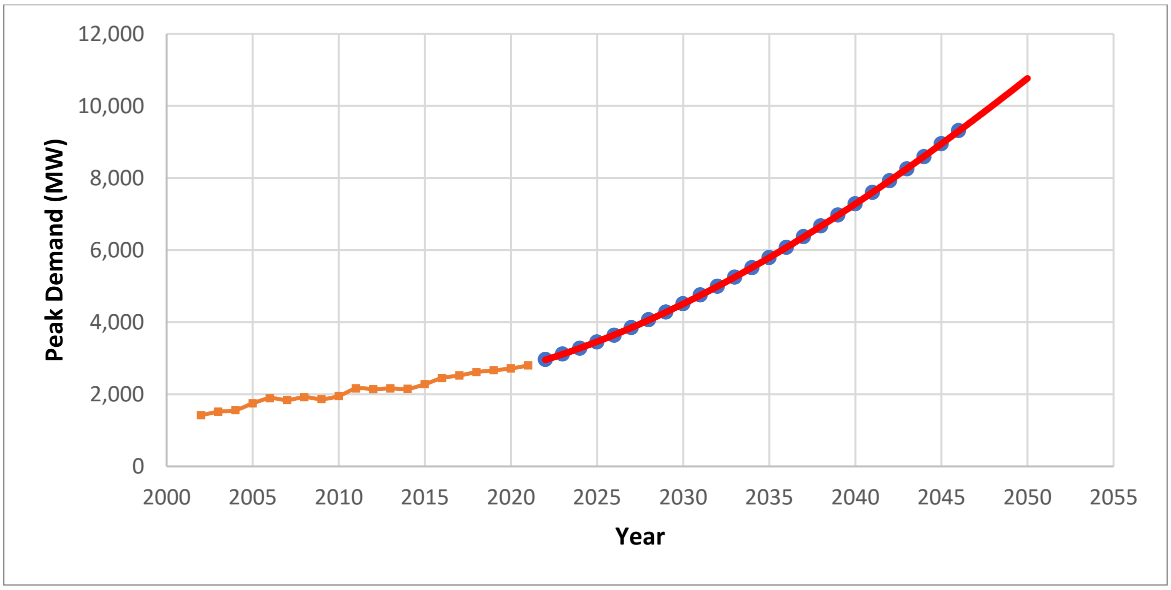


Figure 3.4 : Forecast of Electricity Peak Demand

As per the draft LTGEP 2023-2042, following three scenarios were identified to achieve the general policy guidelines declared by the government (Draft LTGEP 2023-2042). This plan considers power plant 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 2ieving 70 % RE by 2030, maintaining 70% RE beyond 2030, no coal fired plant additions throughout the horizon and considering cross border interconnection with India

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

Based on the forecasted electricity demand up to 2050, the CO_2 emissions of each of the above scenarios are estimated and taken as the baseline scenarios in the power sector.

.

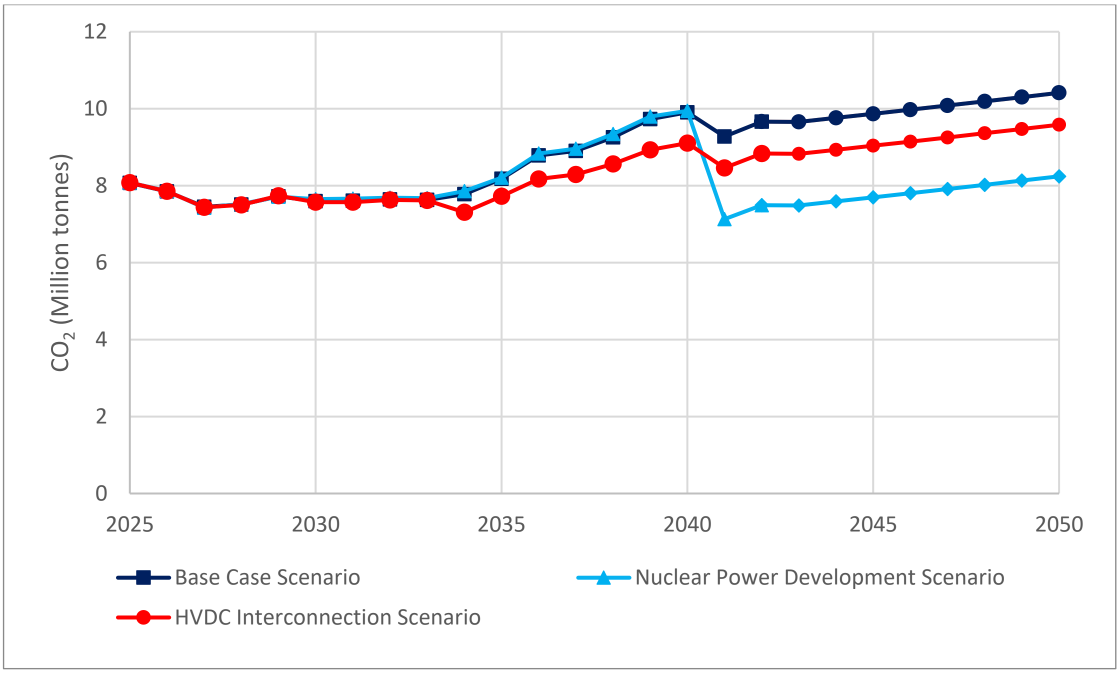


Figure 3.5 : CO_2 Emissions in Baseline Scenarios for Power Sector

The CO_2 emission in the Domestic, Commercial and Other sector (excluding Transport and Industrial sectors) was forecasted by considering forecasted demand of LPG, kerosene, diesel, fuel oil and charcoal. The net emission from firewood and biomass are conceded as net zero. The total CO_2 emission in the Domestic, Commercial and Other sectors is shown in Figure 3.6.

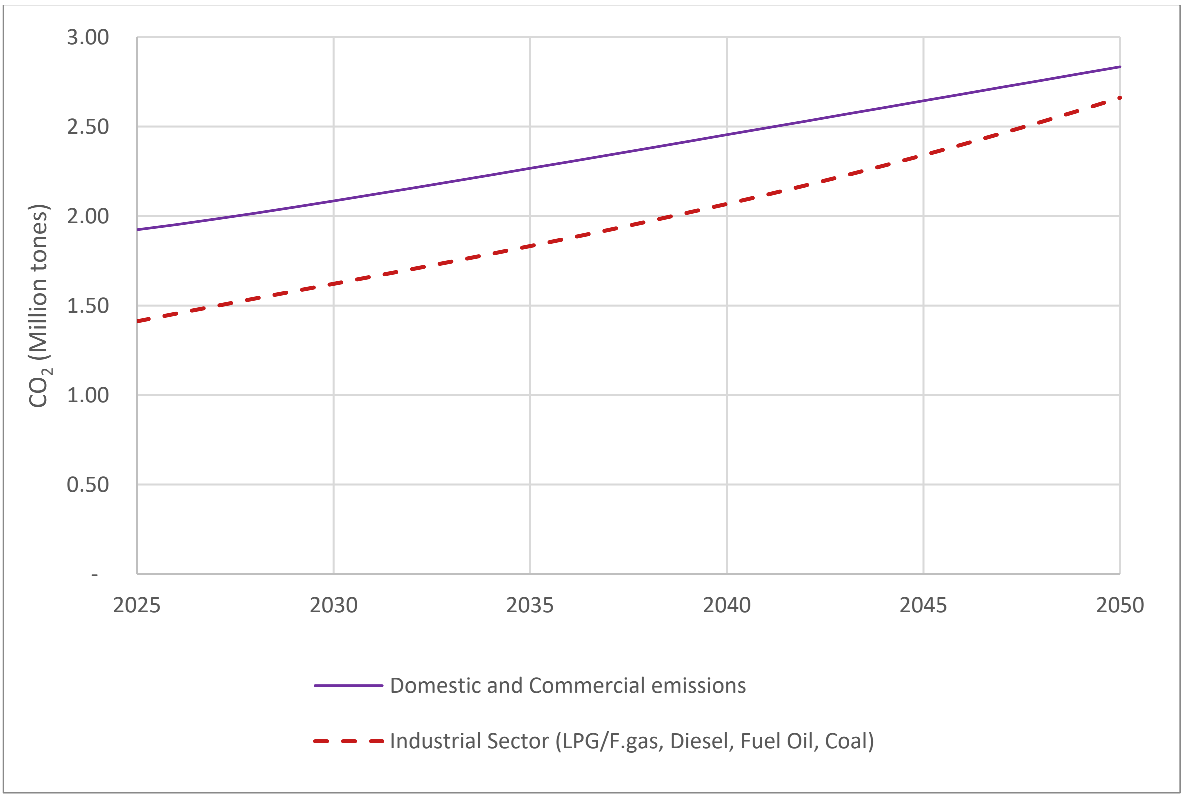


Figure 3.6 : CO2 Emissions in Baseline Scenarios for Household and Commercial Sectors and Industrial Sector

The estimated total CO_2 emissions in the energy sector (excluding fuel used for Transport and Industrial IPPU sectors) for the period of 2025 to 2050 with proposed three baseline scenarios of the LTGEP 2023-2042 are shown in Figure 3.7.

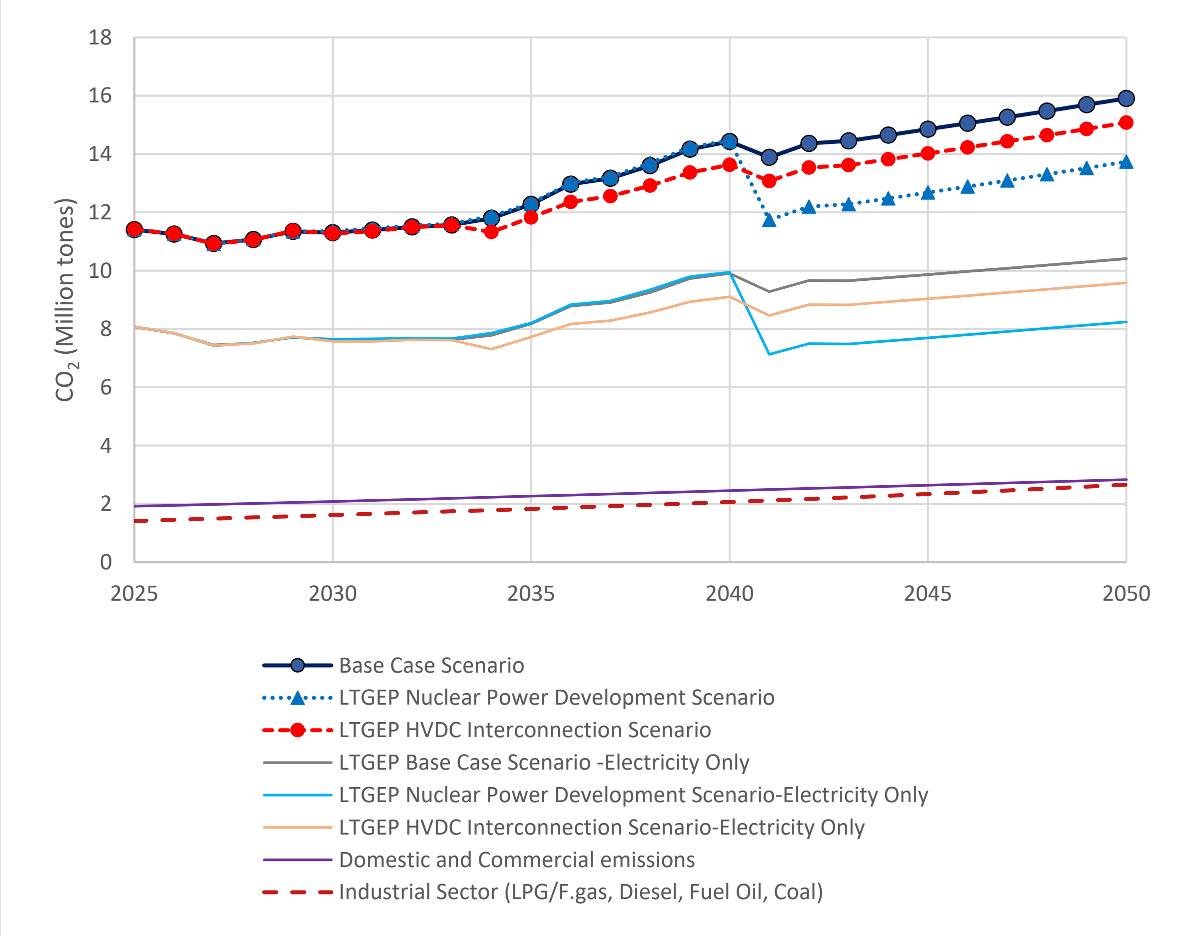


Figure 3.7 : Total CO_2 Emissions in Baseline Scenarios (Excluding fuel used for transport and industrial IPPU sectors)

3.2.2 Transport Sector

Sri Lanka's CO_2 emission by the Transport Sector in 2021 is 11 million tonnes (MoE, 2021), as estimated in the NDC report of the Ministry of Environment. With proposed mitigation measures, it is expected that the implementation of updated NDCs will result in GHG emissions 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, as shown in Figure 3.8.

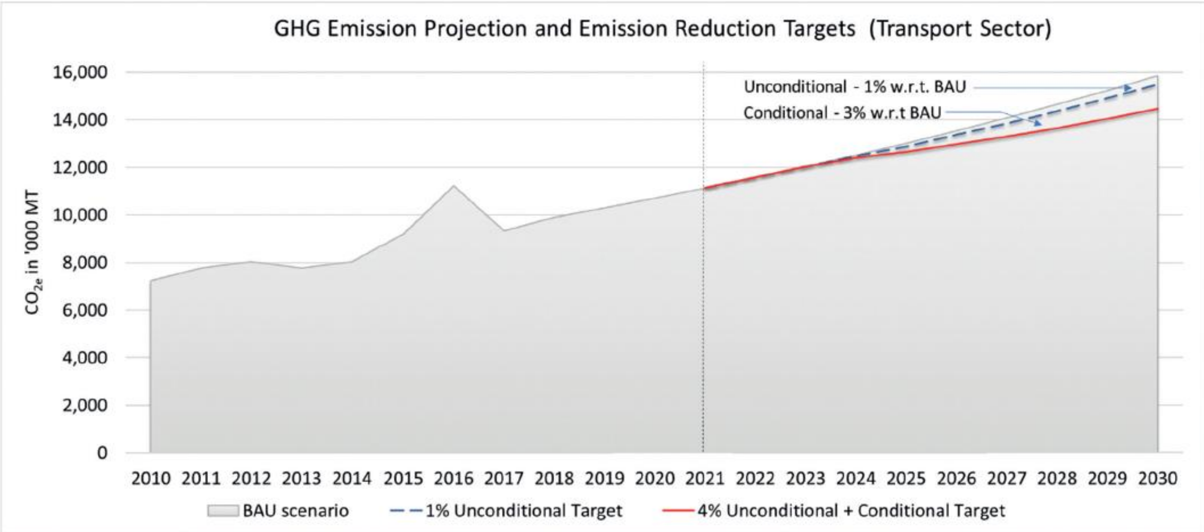


Figure 3.8 : GHG Emission Projection up to 2030

The CO_2 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 emission level relevant to the transport sector. The NDC implementation study interim report (MoE, 2022) shows no significant difference between the emissions in the BAU case and the implementation of unconditional actions during the period 2020 – 2022. Thus, the BAU scenario is considered as the Baseline, where the population and the economy would grow, while no mitigatory interventions are taken in the future. Therefore, the CO_2 emission rates with respect to the parameters such as GDP and Population are analysed using historical data. Figure 3.9 shows how the CO_2 emission per capita has increased with GDP per capita over the period 2008-2019. A sharp increase in rate is observed during the period 2015-16 when the value increased coinciding with the rapid increase in motorcycles and three-wheeler registrations which was observed during the period. Therefore, the observed relationship is used to forecast CO_2 emission quantities for future population and economic growth (reflected by the GDP) scenarios used in the study.

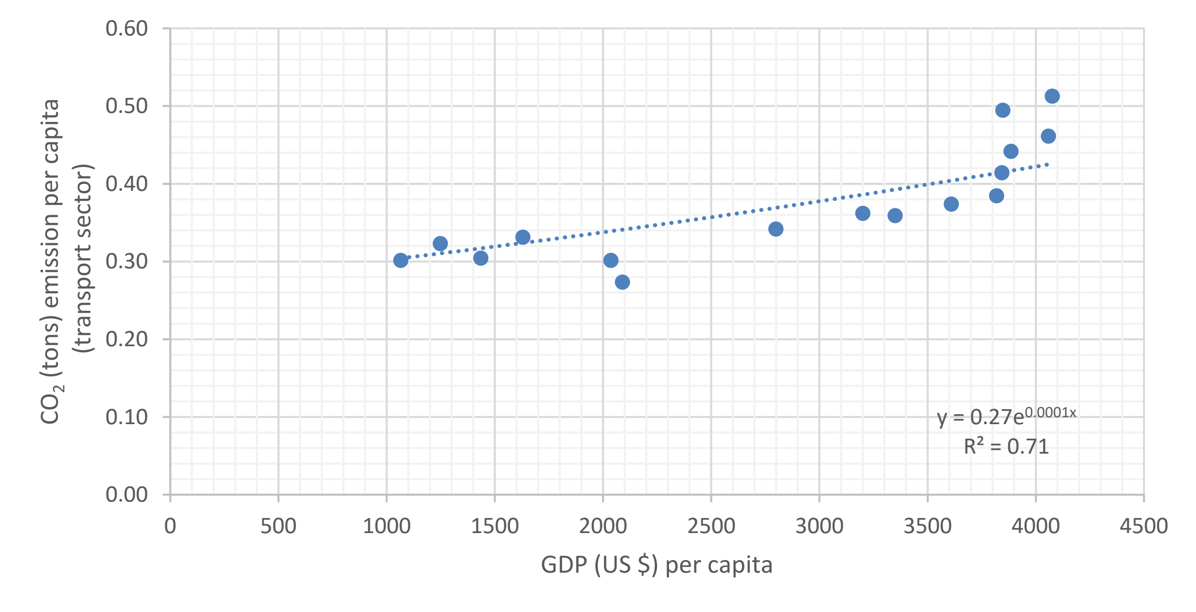


Figure 3.9 : CO_2 emission per capita variation with GDP per capita

3.2.2.1 Baseline scenario CO_2 forecasting for 2050

Sri Lanka has not worked towards generating a transport policy nor a national-level master plan to identify candidate projects that the government has committed to. Regional plans such as the Western Region Megapolis Master Plan (developed in 2015/16) and the COMTRANS study master plan (developed in 2011/12) were not adopted by successive governments. The only strategic level plan that is officially available is the Road Development Authority's Highway Master Plan for 2021-2030, which outlines the highway development needs under the government's economic growth forecast, which was at 6% p.a. Based on the increased transport activity due to the economic growth, the vehicular traffic demand growth rates are adopted to forecast future traffic flows on the road network. The growth rate used in the master plan development is 4% and 3.5% for the period of 2018 – 2025 and 2025 – 2030, respectively (RDA 2021).

According to the World Bank overview, the economic growth forecasts for Sri Lanka for the years 2023 and 2024 are -9% and -4%, respectively. Therefore, the anticipated trip growth rates are unlikely to be applicable until 2025. Hence, the values estimated for 2021 are likely to remain constant up to 2024.

From 2024 to 2050, it is assumed that the GDP growth rate would be equivalent to a 3.1% value based on the project modelling scenario. The population is expected to increase up to 24 million as per the forecasting scenario for the Baseline.

Using the emission per capita and GDP per capita model developed using historical data, 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 $ 7399. At existing emission rates this would give a per capita CO_2 emission rate of 0.79 tonnes.

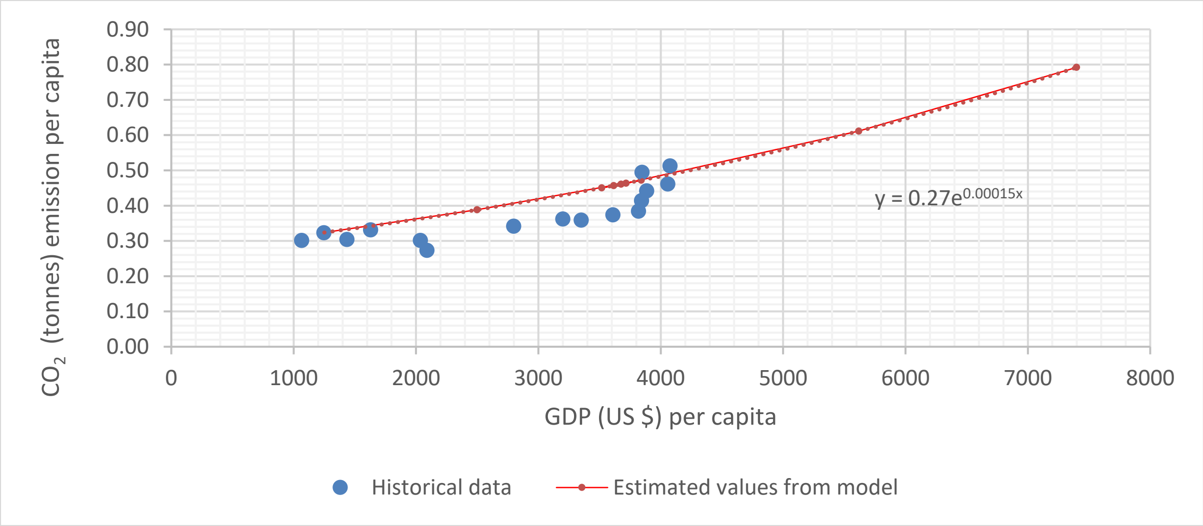


Figure 3.10 : CO_2 estimation from model

Thus, as shown in Figure 3.11, the forecasted CO_2 emission for 2050 is 19 million tonnes.

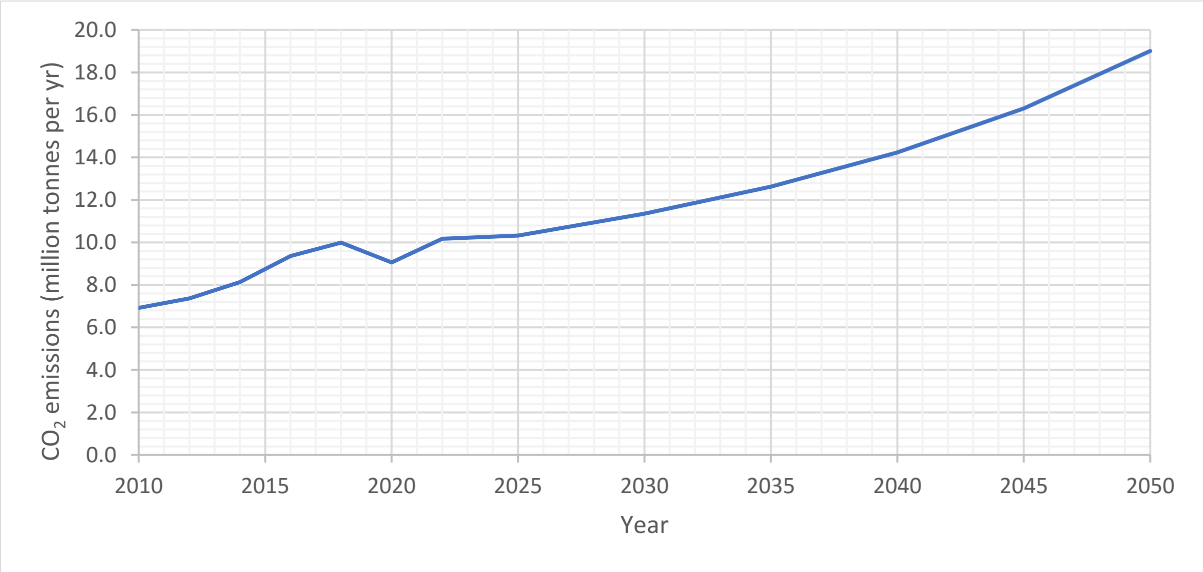


Figure 3.11 : CO_2 estimation for the transport sector

If we use the linear regression analysis-based forecast using the historical data in the Climate Analysis Indicators Tool (CAIT) tool, the forecasted value is 24 million tonnes. Therefore, it can be considered a prudent estimate considering that for close to 4-5 years during this period there is significant reduction in economic activity.

3.2.3 Industry Sector

Considering the national economic development and population growth indices, the total emissions for the Baseline scenario and the mitigation (net zero) scenario were calculated, and depicted in Figure 3.12.

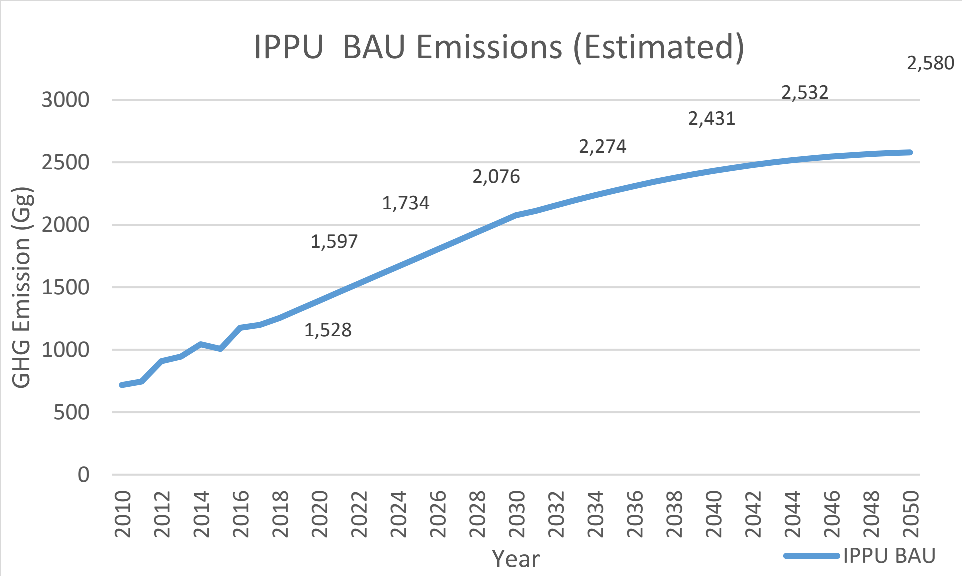


Figure 3.12 : The GHG emissions by the Industry IPPU, predicted for the period 2025 to 2050 under the Baseline Scenario

3.2.4 Waste Sector

The scenarios considered to quantify GHG emissions by 2050 in the waste sector are,

A. **Baseline**: Business-as-usual scenario (BAU) + NDC Unconditional
B. Net-zero (Mitigation) scenario

A. Baseline: Business-as-usual scenario (BAU) + NDC Unconditional

Nationally Determined Contribution (NDC) unconditional actions up to 2030 are considered as the Baseline scenario and NDC unconditional actions were modeled for the prediction up to 2050, as shown in Figure 3.13.

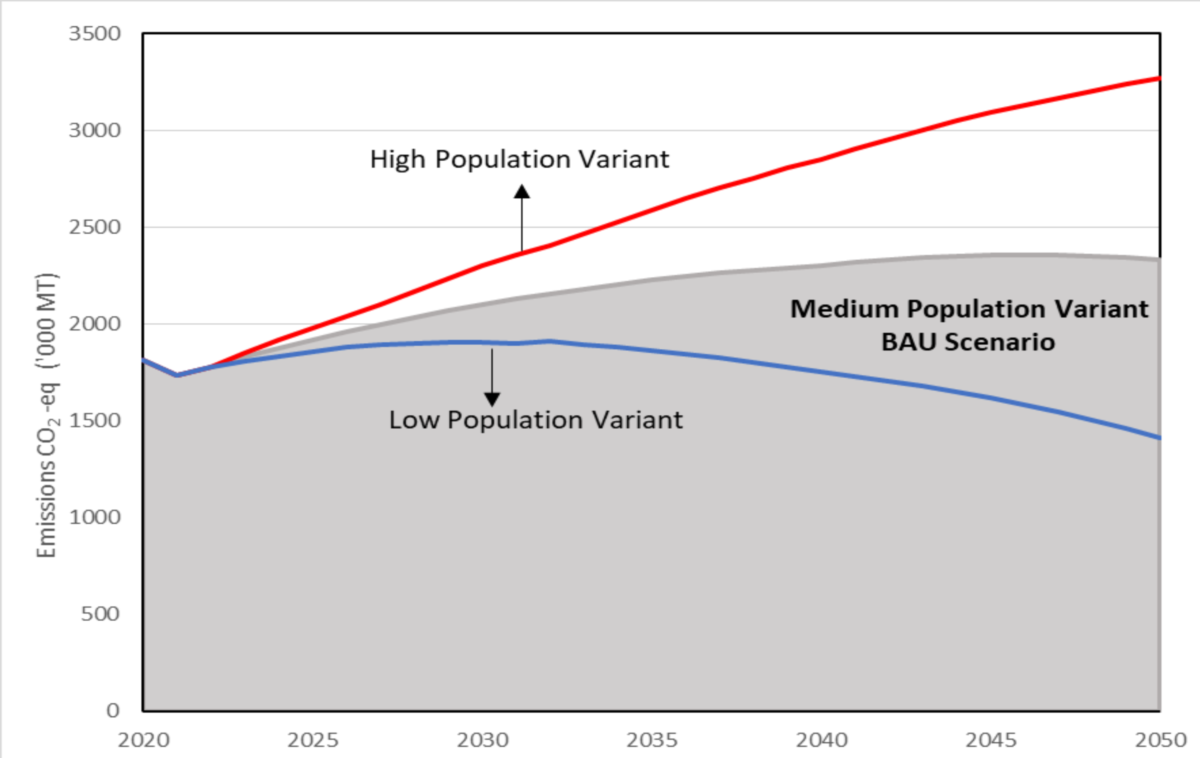


Figure 3.13 : Baseline scenario

Considering the Population Predictions from the United Nations (UN, 2022), three different variations were considered with high medium, and low variations in population in the country with a 3.1% GDP growth rate as given in the Sri Lanka Climate Prosperity Plan Preliminary report. The medium variant population shows a more realistic variation in the GHG emission since the population growth during the latter years during the study period decreased, which as well indicates there could be a natural tendency in the reduction of GHG in the future.

B. Net-zero (Mitigation) scenario

Nationally Determined Contribution (NDC) unconditional and conditional actions up to 2030 are considered as a scenario to understand the pattern of GHG emission if the NDCs' actions were followed promptly. The multiple variant population from the United Nations (UN, 2022) and 3.1% of GDP from CPP were used for the prediction of emissions in the NDC scenario. Figure 3.14 shows the situation of GHG emissions in this scenario.

Here too, the medium variant population shows a more realistic variation in the GHG emissions, since the population growth during the latter years during the study period decreased, which as well indicates there could be a natural tendency in the reduction of GHG in the future. This scenario will be considered to which the proposed mitigatory actions to be incorporated in seeking the net zero emission within the sector.

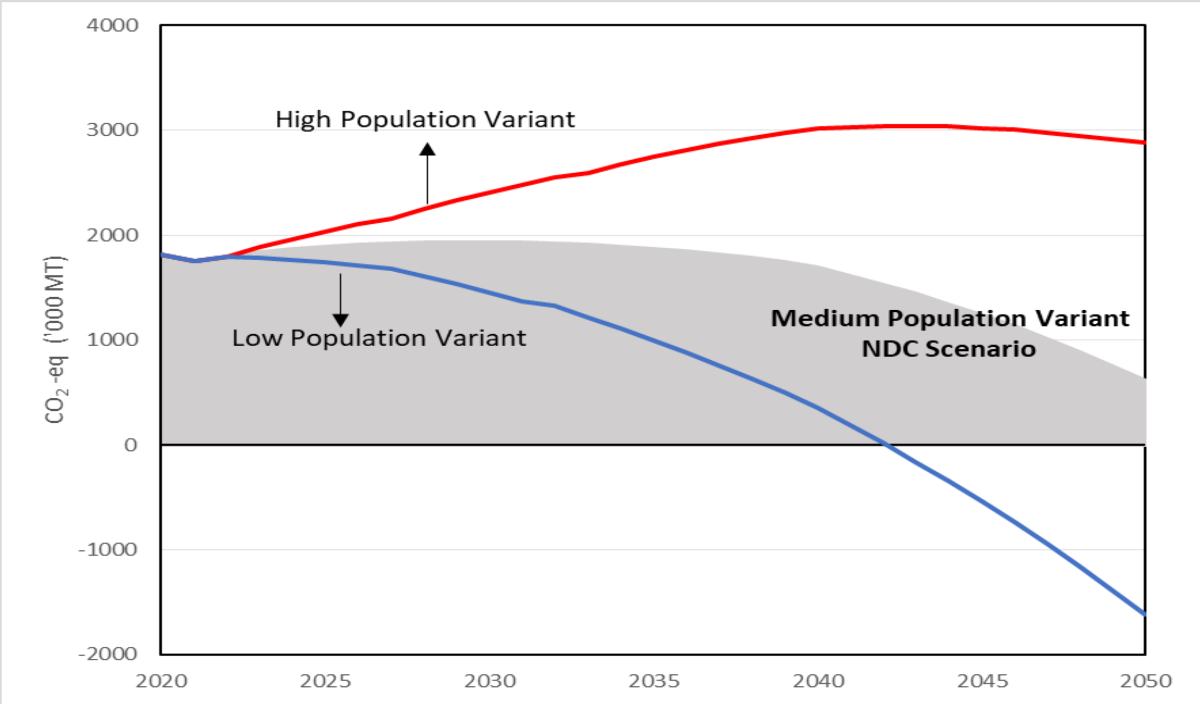


Figure 3.14 : NDC scenario

3.2.5 <u>Agriculture Sector</u>

Emission prediction models for the agriculture sector are limited as many prediction models in agriculture sector are focused to predict yield and production of various crops. Some models found are discussed below with their disadvantages for the present purpose. Prediction of emissions based on NDC approach has been found as the most suitable model scenario development.

FAO EX-ACT Model

The Ex-Ante Carbon-balance Tool (EX-ACT) is an appraisal system developed by FAO (2013b) providing ex-ante estimates of the impact of agriculture and forestry development projects, programmes and policies on the carbon-balance. The carbon-balance is defined as the net balance from all GHGs expressed in CO_2eq that were emitted or sequestered due to project implementation as compared to a business-as usual scenario. The EX-ACT is a land-based accounting system, estimating C stock changes (i.e. emissions or sinks of CO_2) as well as GHG emissions per unit of land, expressed in tonnes of CO_2e per hectare and year. The tool helps project designers to estimate and prioritize project activities with high benefits in economic and climate change mitigation terms. The amount of GHG mitigation may also be used as part of economic analysis as well as for the application for funding additional project components.

Disadvantage – All data required for the model inputs are not available for Sri Lanka.

Machine Learning (ML) models

Machine learning (ML) models are increasingly used to study complex environmental phenomena with high variability in time and space. There are 3 categories of models namely classical regression models, shallow learning models and deep learning models for predicting soil greenhouse gas (GHG) emissions from an agricultural field. Carbon dioxide (CO_2) and nitrous oxide (N_2O) fluxes, as well as various environmental, agronomic and soil data are required as inputs. According to the Hamrani et al. (2020), the rigorous analysis which included statistical comparison and cross-validation for the prediction of CO_2 and N_2O fluxes, confirmed that the Long Short-Term Memory (LSTM) model performed the best among the considered ML models with the highest R coefficient and the lowest root mean squared error (RMSE) values

Disadvantage - One of the fundamental problems of time-series data mining is the representation of the data. Hence, time-series data forecasting without any data clustering requires that one model to be built for each pixel. This requires significant computational effort and validation of a substantial number of models (Vasilakos et al., 2022).

Scenario development

Baseline Scenario – The reference curve has been fixed considering GDP and population change as baseline scenario (Figure 3.15). Two exceptional lowering of emissions was observed in the year 2014 and 2016 and according to DOA it was due to the impacts of an El Nino condition prevailed in Sri Lanka.

NDC 2030 scenario extended to 2050 – The GHG reduction curve established on the assumption that the mitigation strategies mentioned in 2030 report are adopted continuously up to 2050. Figure 3.16.

Mitigation Scenario – This scenario is recommended by this report including following additional changes: Figure 3.17

i. In livestock sector all cattle population and goat and sheep populations were included

ii. A strategy was included to remove paddy straw from all types of paddy fields. The paddy straw provides high C:N ratio and leads to emit more methane if mixed in the soil. Removal of paddy straw from the field and less disturbance to soil through conservation tillage will minimize GHG emission due to microbial activities in the soil.

This improvement could further reduce GHG emission down to 61 %.

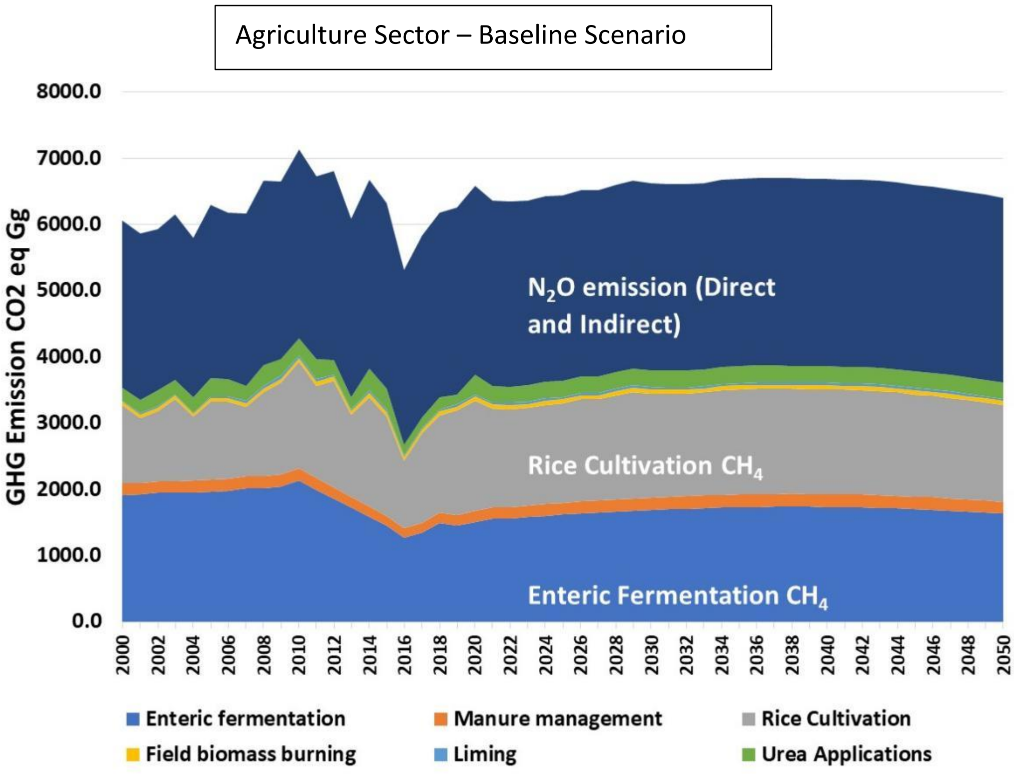


Figure 3.15:The GHG emissions from various activities under Agriculture, contributing to emissions from the Agriculture Sector

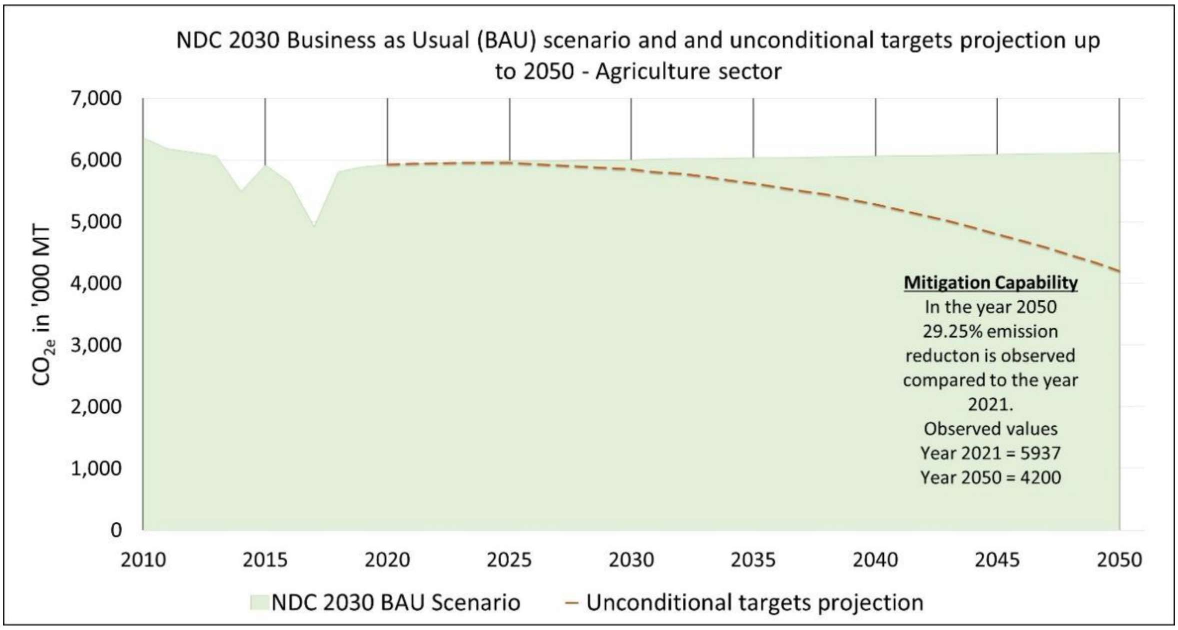


Figure 3.16 : Extrapolated BAU and Unconditional Targets scenarios for the Agriculture sector as per NDC report (MoE, 2021)

However, it was observed that Agriculture sector covered by the updated NDC Sri Lanka needs further improvements prior to be used to predict and forecast 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 were categorized in to milking, not milking, 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 to that 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 NDC 2030 report) is not much encouraged due to the facts that paddy production should be kept stable and all paddy soils are not suitable for crops like soybean, onion, groundnut etc.

The above refinement is shown in Figure 3.17 and the respective GHG emissions due to methane, carbon dioxide and nitrous oxide is shown in Figure 3.18. This approach helped to increase the mitigation capability of the incremental planning proposed for five-year intervals up to the year 2050 and percentage reduction obtained from the best-case scenario was used to formulate the mitigation planning.

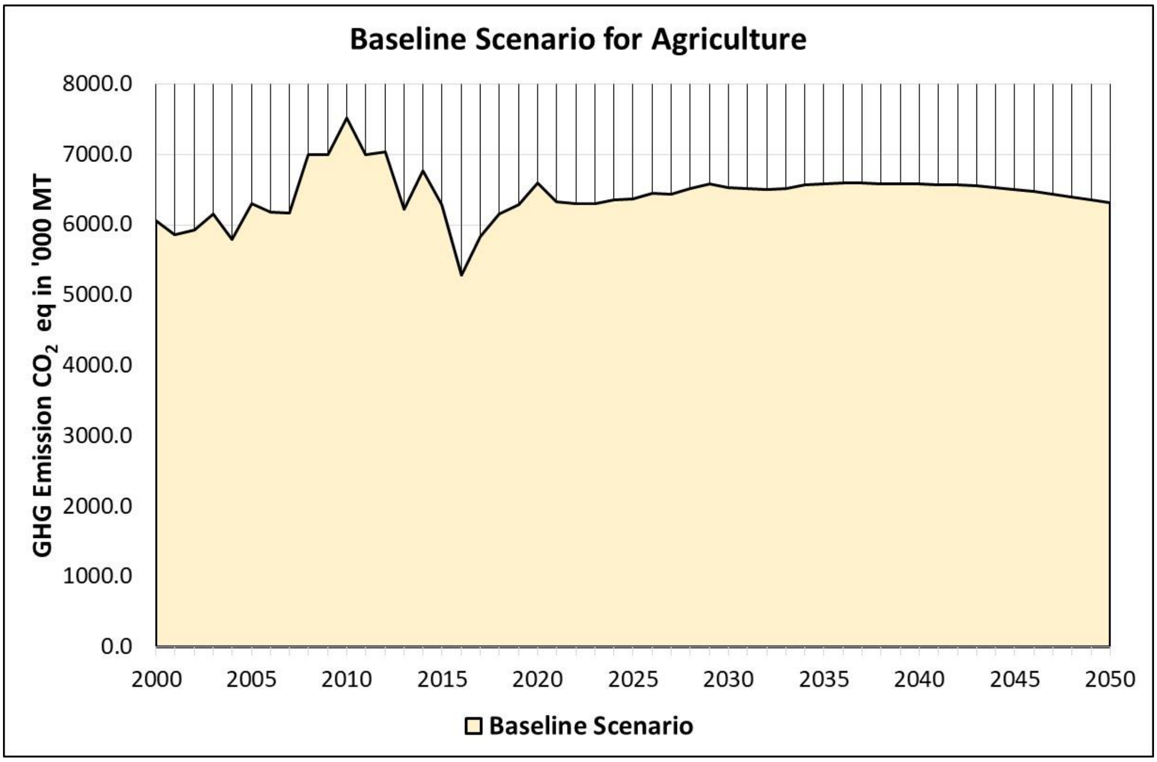


Figure 3.17 :Baseline Scenario developed for the Agriculture

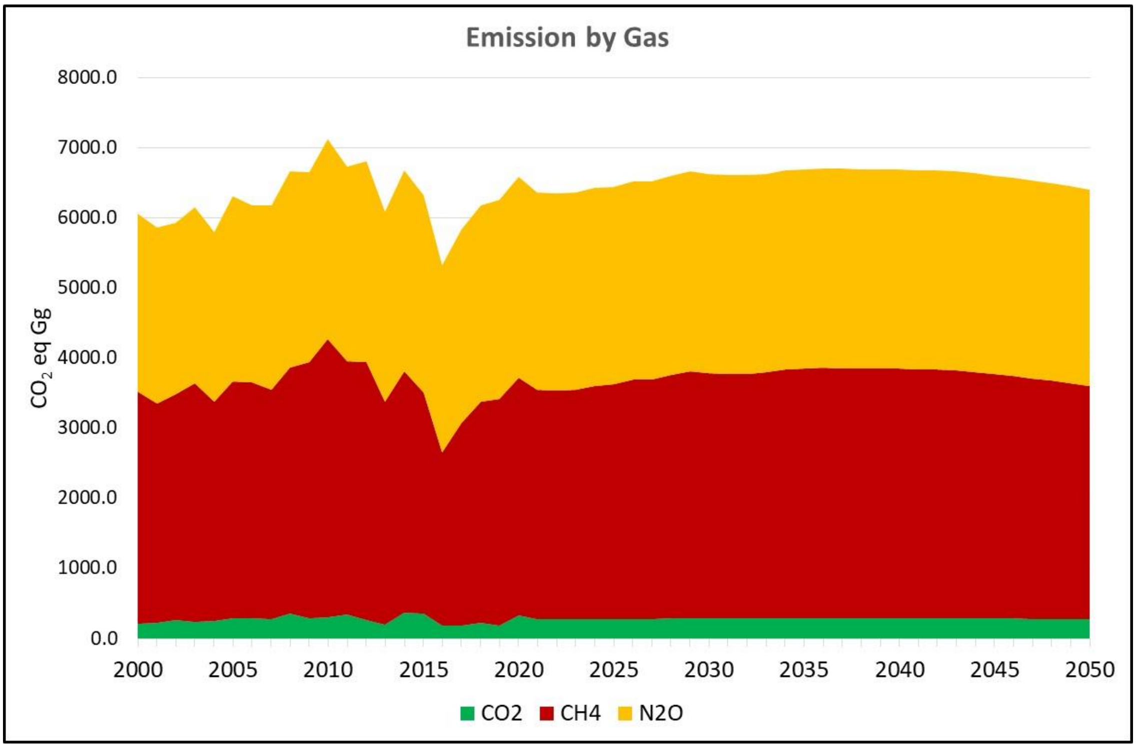


Figure 3.18 :Contributions of CO_2, Methane and N_2O to the total GHG emissions from the Agriculture sector

According to the Figure 3.18 developed on the basis of emission model formulated for the Carbon net zero 2050 study, Methane and Nitrous Oxide gases could be considered as major contributors for the agriculture sector compared to the CO_2 emissions. Hence, it was decided to analyze only CH_4 and N_2O gases as GHG contributors.

Carbon Sequestration from the agriculture sector

The carbon sequestration capacity of tea plantations has not been accounted for in the updated NDC Report (2022) or the TNC (2022). However, these values were calculated for this report, and are given in Table 3.2.

The tea plantations in the low country, mid-country, up country, and Uva have the potential of sequestering 6659, 3497, 2344, and 5085 kg of C ha-1 yr-1 respectively. Potential values for C sequestration were calculated accordingly. These values can be used in C net zero balance exercise.

Other plantation crops and the home garden were not considered under agriculture as these are considered under forestry sector (trees outside the forest)

Table 3.2: Present C sequestration in tea lands

	Low Country	Mid Country	Upcountry	Uva	Total
C sequestration (Kg/ha/year)	6,659	3,497	2,344	5,085	-
Land extent (ha)	13,883	6,358	35,432	25,919	81,592
Baseline C sequestration Mt/ year	92,447	22,234	83,053	131,798	329,532

Source: Wijeratne et al, (2014)

In order to improve the biodiversity in Tea plantations, fruit trees which produce small berries could be introduced. This could be done as land strips having one meter width running along the foot of hills having tea plantations. This will add a separate mini ecosystem to tea lands and will support most of the pollinators which will again support to keep the vegetation cover Gunasena 2016.

However, since the plans or data for enhancement of sequestration are not available for reliable calculations, and these values are not significant compared to the sequestration by the Forestry sector, these were not accounted for the carbon net zero calculations.

3.2.6 <u>Forestry Sector</u>

Baseline Scenario refers 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:

A. Forest cover includes natural forests, forest plantations and rubber plantations according to the definition of forests by FAO.
B. The deforestation rate will be 5000 ha/yr from 2021-2030 as per the Revised Nationally Determined Contributions (NDCs) (Ministry of Environment, 2021). This will continue up to 2050.
C. The new plantings will be 18,050 ha from 2021-2030 according to the Ministry of Environment, (Revised NDC, 2021-2030, Ministry of Environment, 2021) 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. In home gardens, the annual increase was taken as 1%, while the annual loss was taken as 0.3%
F. In the coconut plantations, the annual loss was taken as 616 ha, while the annual increase was taken as 10,000 ha.

G. In the tea plantations, annual increase was taken as 1800 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.

Following Reference values were taken in the calculations:

Emission Factors

a) 150 tons/ha in deforestation and establishment of new forest lands and conversion of home gardens to other non-tree land uses.
b) 100 tons/ha in fragmentation of coconut lands and replanting of coconut lands, removal of mangrove lands, removal of urban forests, replanting of tea lands;
c) Due to the scattered nature of plantings this was not considered in mangroves and urban tree cover.

Carbon sequestration factors

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; 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 1 in Annexure 3) shows the projected extents of forests (natural forests, forest plantations and rubber plantations), Trees outside the forests (homegardens, coconut plantations, shade trees in tea estates, trees in settlements, trees in urban environments and avenue plants) and mangroves in the Baseline Scenario, estimated annually over the period 2025 to 2050. The estimated Total Carbon Sequestration in Forests, Trees Outside Forests and Mangroves in the Baseline Scenario is shown in Table 2 in Annexure 3).

The Projected Carbon Sequestration for the Baseline scenario in the Forestry Sector is shown in Figure 3.19.

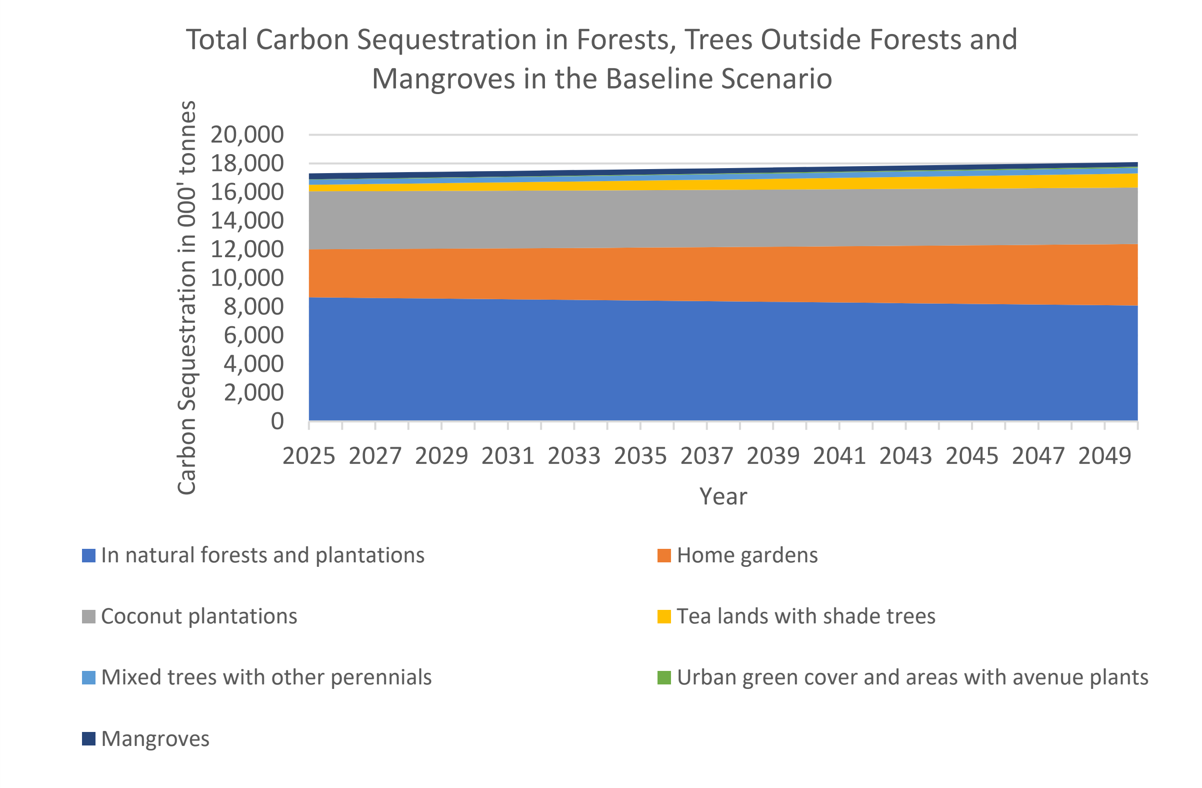


Figure 3.19: Projected Total Carbon Sequestration in Forests, Trees Outside Forests and Mangroves in the Baseline Scenario

The emissions due to deforestation of forests, removal of mangroves and loss of trees outside the forests including coconut plantations and home gardens were taken into consideration. The calculated total GHG emissions from the Forestry sector including forests and trees outside forests (tonnes /yr) in the Baseline Scenario from 2025-2050 is shown in Table 3 in Annexure 3, and Fig 3.20

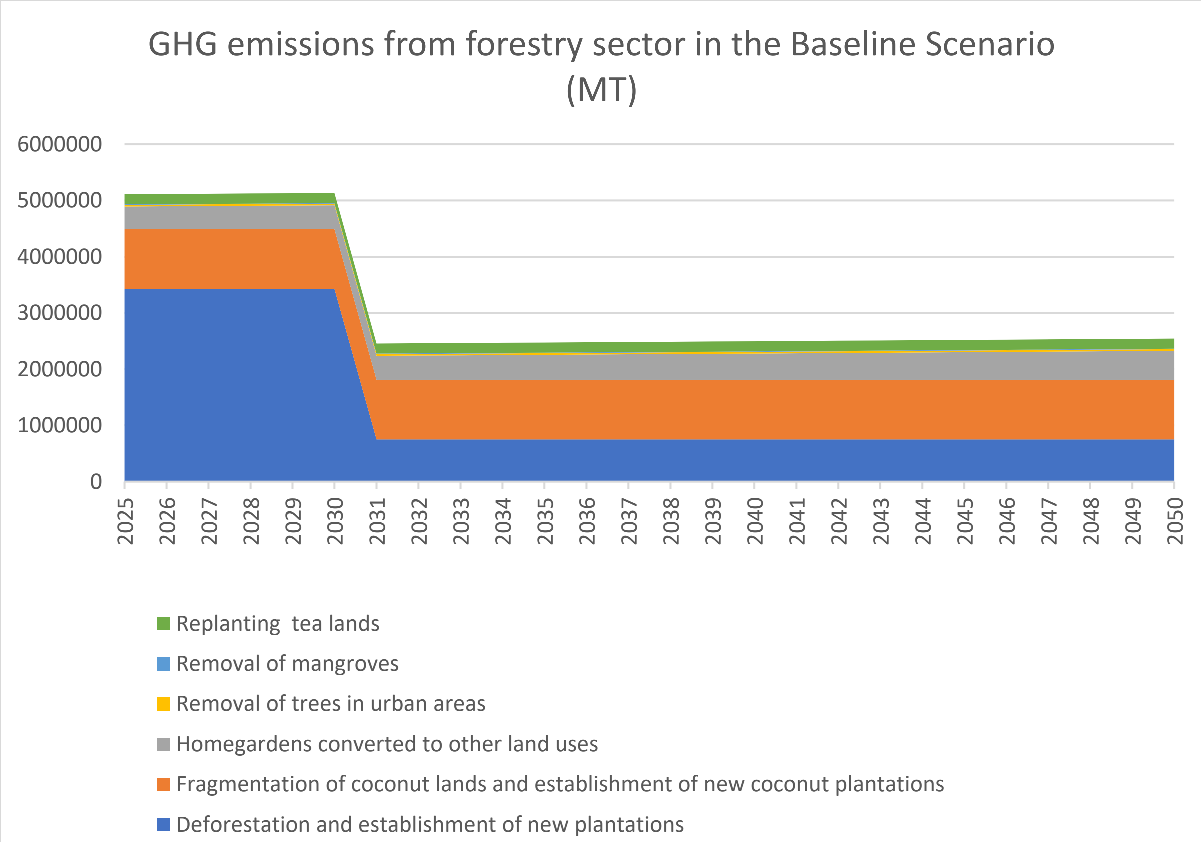


Figure 3.20 : The total GHG emissions from the forestry sector including forests and trees outside forests (tonnes/ha/yr) in the Baseline Scenario from 2025-2050

3.2.7 Overall Net Emissions in the Baseline Scenario

The net emission levels (total emissions - total sequestrations) is shown as a white line graph in Fig 3.21, and this shows an increasing trend throughout the period 2025 to 2050. As seen in Fig 3.21.and Table 3.3, the Baseline scenario would result in a net annual emission quantity of 23,621,843 MT (23.62 Mt) CO_2e by the year 2050. In order to achieve Carbon Net Zero by 2050, this net emissions value has to be reduced by mitigation actions in all sectors, so that the emissions are reduced and sequestrations are increased to balance each other.

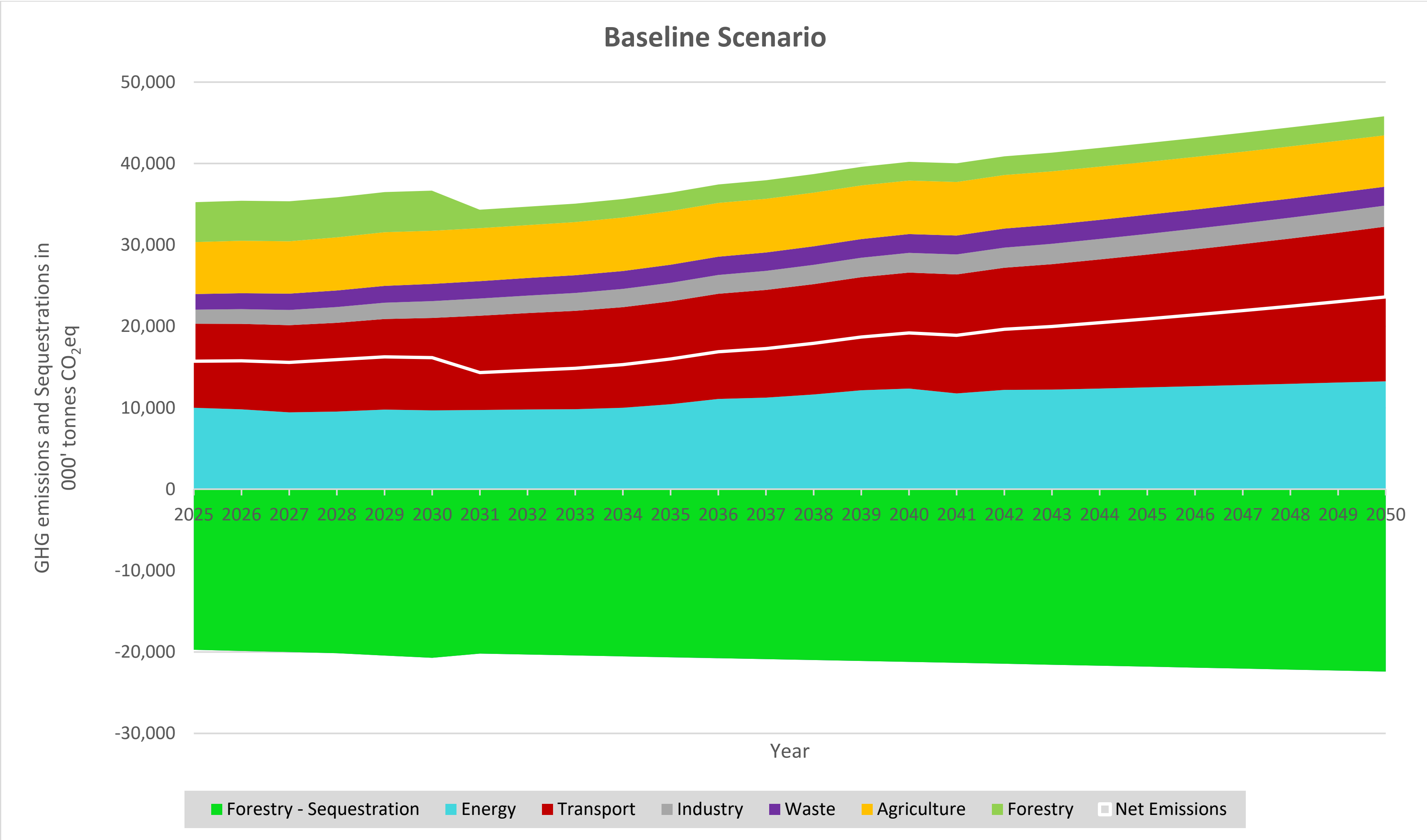


Figure 3.21 : The Predicted Emissions and Sequestration in All Sectors for the Baseline Scenario

Table 3.3: 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

3.3 The Mitigation Scenario

The Mitigation scenario is one where the GHG emissions are reduced to the lowest possible, and sequestration is increased to the maximum, where relevant, in all six sectors with proposed actions and timeline for the implementation.

As explained in section 3.1.1 of this report, a preliminary study revealed that it would be possible to achieve net zero emission status by 2050 (or even before 2050), if all mitigation actions proposed for each sector by the consultants, which went beyond the NDC actions, were to be implemented as proposed, in a timely manner. Therefore, the Mitigation Scenario was taken as the Net Zero Scenario."

3.3.1 Energy Sector

Rapid decarbonization of the power sector is a crucial step toward achieving net zero, both because the sector currently accounts for about 8,400 tonnes of GHG emissions and because electricity demand is expected to increase as emissions are abated in other sectors via electrification. Power sector policy will in large part determine the speed and extent of the sector's decarbonisation. 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 decarbonised power system. Therefore, acceleration of deployment of low-cost renewable generation, such as offshore and onshore wind and solar, large-scale nuclear plant and cross border power interconnections are considered as key commitments. Furthermore, generation of green hydrogen can also be considered as an option that can contribute to energy security, lowering emissions and system costs in the future. Following key mitigation actions are considered as the strategies to reduce GHG emissions in the energy sector.

Pathway 1:

- 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 2x300 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 will 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.

  However, the Long-Term Green Energy Plan (LTGEP) for the period 2023-2042 has brought to light significant challenges in achieving even an 80% renewable energy share by 2040. A major concern is the potential uneconomical levels of renewable energy spillage, which hinder the realization of the desired 80% RE share. Moreover, the projected demand profile's inability to absorb renewable energy generation has resulted in a considerable amount of curtailed renewable energy, even at an 80% RE share. These observations raise valid concerns about the feasibility of scaling beyond this threshold, as it could lead to a substantial increase in investment costs compared to the Base Case and cast doubts on the sustainability of operational expenses.

  Nevertheless, there is hope for the future, as rapid advancements in RE integration technology and energy storage solutions are expected. These innovations may pave the way for the eventual goal of achieving a 100% renewable energy-powered energy sector in the future. It is crucial for policymakers and stakeholders to invest in research, development, and implementation of these technologies to unlock the full potential of renewable energy and steer the country towards a greener and more sustainable energy landscape. By embracing technological progress and ensuring a conducive environment for renewable energy growth, Sri Lanka can make significant strides towards a cleaner and carbon-neutral future.

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 plants additions after 2039.
- No expected pumped storage to be introduced after 2032.

To avoid renewable energy (RE) curtailment and enhance its economic viability, the introduction of green hydrogen technology holds great promise for Sri Lanka. However, before proceeding, it is crucial to acknowledge that no proper assessment of the hydrogen industry in the country has been conducted yet. Therefore, a detailed feasibility study must be undertaken immediately to lay the groundwork for its successful implementation.

The initial step in establishing a green hydrogen industry would involve strategic investments in renewable energy sources like solar, wind, and hydropower to generate the required electricity. These renewable energy projects should be carefully located to maximize energy production and minimize transmission losses. An indispensable aspect of this endeavor is the establishment of electrolysis plants, where surplus electricity generated from renewables will be used to split water into hydrogen and oxygen. By employing this process, the produced hydrogen will be entirely green, devoid of carbon emissions.

Fostering partnerships between the government and private sectors becomes crucial to support industries. Offering incentives and favorable policies can attract investments in the green hydrogen value chain. Encouraging industrial sectors to transition from conventional fossil fuels to green hydrogen can significantly reduce their carbon footprint and accelerate the country's progress towards achieving carbon net-zero.

To ensure sustainable growth, investing in research and development becomes vital. This will advance green hydrogen technologies, leading to increased efficiency, cost-effectiveness, and safety, which will further attract innovation and drive industry expansion. Public awareness campaigns and educational programs should be launched to promote the benefits of green hydrogen and drive its adoption across various sectors. Engaging the public in this transition will instill a sense of responsibility and foster collective efforts towards achieving carbon neutrality. International collaboration and partnerships will play a pivotal role in knowledge exchange, technology transfer, and accessing global markets for green hydrogen. Drawing insights from successful green hydrogen initiatives in other countries will help fine-tune Sri Lanka's approach.

By implementing a robust green hydrogen industry with unwavering support for industries, Sri Lanka can pave the path towards carbon net-zero, simultaneously fostering economic growth and sustainability for the nation. By considering all above facts, initiating the first project in the year 2032 is considered in the carbon net zero roadmap.

Figure 3.22 shows the predicted GHG emissions for the period 2025 – 2050 under several scenarios that were considered, which includes 3 scenarios considered in the LTGEP, and 2 scenarios studied in this study, viz Proposed Mitigation Scenario for Power Sector Decarbonization and Proposed Mitigation Scenario for Energy Sector Decarbonization, the last being the option that would be most desirable to reach Carbon Net Zero for Sri Lanka.

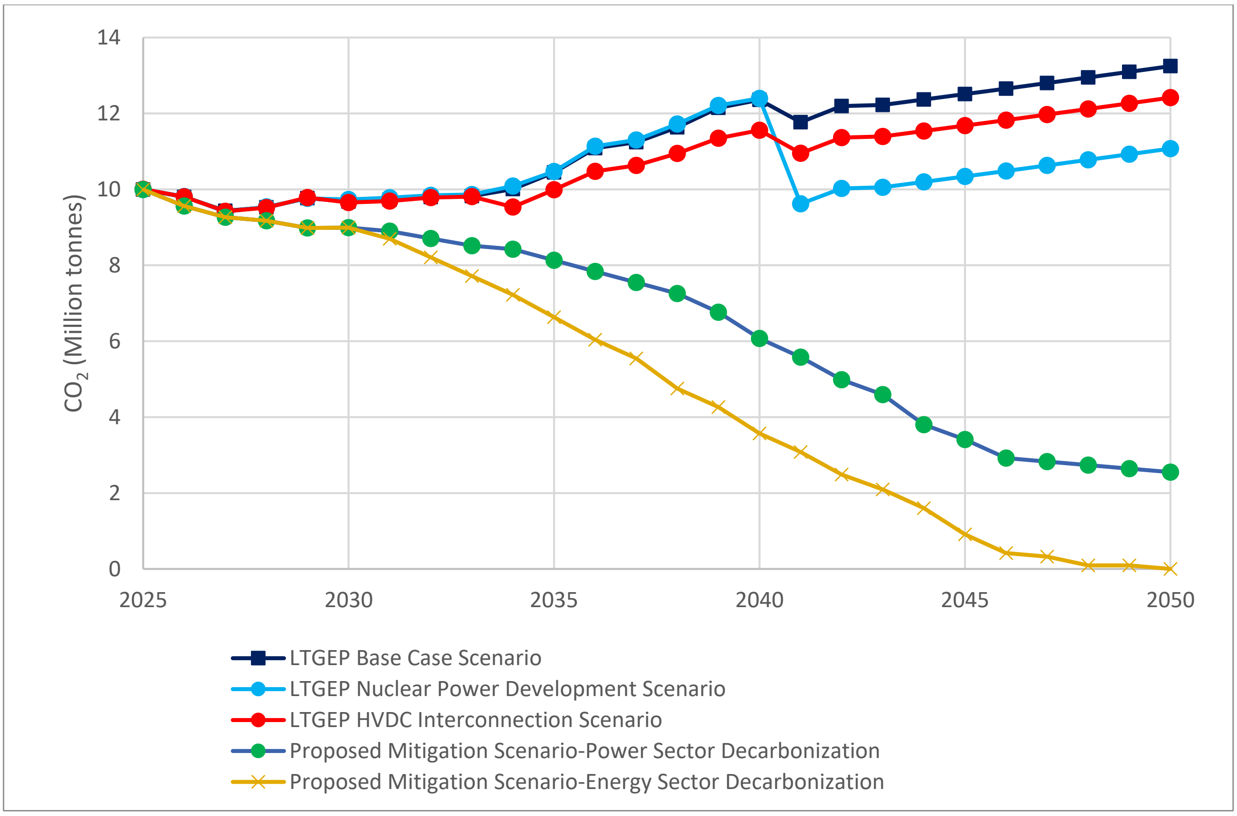


Figure 3.22 : Net Zero Mitigation Scenario in Energy Sector

3.3.2 <u>Transport Sector</u>

The proposed intervention focusses on identifying short term and long-term interventions as well as those that are high capital intensive 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-saving projects from the transport sector is given below, details of which is given in the mitigation strategies section.

a. Promote non-motorized transport: increase modal share of walking and cycling for short distance trips
b. Facilitate remote working and e-commerce, e-learning to reduce the travel demand
c. Bus fleet expansion and modernization
d. Pricing strategies for fuel
e. Transport Demand Management in Cities
f. Develop the LRT network
g. E-mobility: electrification of railway, buses and private vehicle fleet.

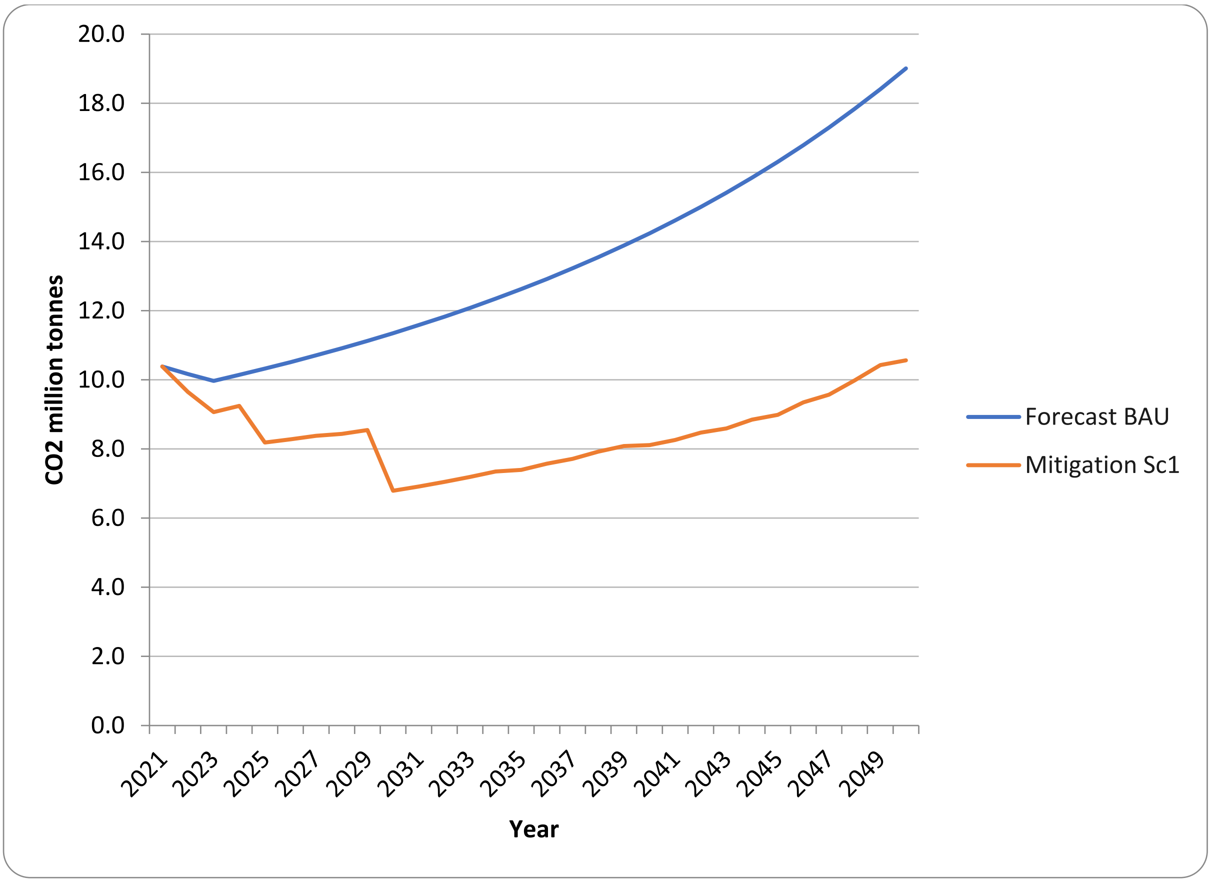


Figure 3.23: The Emissions predicted for the Transport sector under the Baseline and Net Zero scenarios

3.3.3 Industry Sector

As IPPU emissions are highly process specific, very limited opportunities available in reducing emissions (mitigations). Sub sector specific opportunities are listed below;

Cement Industry

Based on the 2000 -2010 cement manufacturing data provided in TNC, 65% of the IPPU emissions are coming from the cement sector (figure 2.aa Page 7).

According to the process studies made during the Greenhouse gas emission reduction from the industries in Asia Pacific (GERIAP 2003 – 2006) at the Puttalam cement manufacturing facility (the only composite cement operation in Sri Lanka) , observed the quality variation of the main raw material lime was not very consistent, due to the geological conditions of the lime query. Hence the industry has taken all possible measures to maintain the process efficiency and product (clinker) quality, which assumed to be the optimum effort to minimize process emissions as well as clinkering process or pyro-processing related energy (coal) and related GHG emissions.

In general application of Cleaner Production (CP) strategies are recommended in minimizing both process and energy use emissions.

As a future emerging and currently emerging option, uses of green hydrogen as a thermal energy source in cement industry for the pyro-processing will be seriously considered as a highly feasible GHG mitigation option, needs to be addressed under the industry energy use.

However, further emission reduction or mitigation potentials or any process specific initiatives to be negotiated and provided by the responsible industry.

In general, subsequent to the maximum effort in minimizing the process-based emissions, remaining emission quantities are recommended to offset with national forestry development plan or “Carbon Capture and Storage” (CCS) strategy or “Carbon Capture, Utilization and storage” (CCUS) strategy appropriate to the industry and viable to the business operation.

Lime industry

Based on the 2000 -2010 lime manufacturing data provided in TNC, 28% of the IPPU emissions are from the lime industry sector (figure 2.aa Page 7).

Currently the main feedstock to the lime industry is dolomite (mixture of $CaCO_3$ and $MgCO_3$) and the main fuel used is firewood logs.

For the GHG inventory development process, the lime production is estimated using the mining licences issued for the purpose by the National Geological Survey and Mines Bureau (GSMB). As there is no post mining quantity assurance process it was assumed that the mining has occurred.

Mined dolomite is subjected to thermal heating process using firewood logs as the source of energy. Dissociation of $MgCO_3$ and $CaCO_3$required 480 ^{O}C and 900 ^{O}C temperatures respectively at the kiln, due to poor thermal efficiencies the expected temperatures are not reached uniformly due to the kiln design and operational inefficiencies. Therefore, the estimated GHG emission values are not highly accurate.

However, the CO2 emission is inherent to the industry and total emission mitigation is unavoidable.

As remedial measures in minimizing emissions adoption of cleaner production technologies are highly recommended. Further, the adaptation of process improvement technologies will provide opportunities to minimize the emissions while product quality improvement.

As GHG mitigation options, Carbon Capture and Storage (CCS), Carbon Capture, Utilization and Storage (CCUS), Forestry or any other offsetting strategies are recommended.

Glass industry

According to the 2000 -2010 glass industry data provided in TNC, 2% of the IPPU emissions are from the glass manufacturing sector (figure 2.aa Page 7).

Use of Soda ash (Sodium carbonate), Dolomite (Sodium Magnesium Carbonate) and Calcite (a carbonate mineral and the most stable polymorph of calcium carbonate) are the main sources of IPPU GHG emissions in the glass industry. In addition to the IPPU emissions, glass industry contributes heavily to the industry energy use related GHG emissions due to its inherent thermal energy requirement for raw material smelting process needs. Use of Green Hydrogen for the industry thermal applications will be one of the potential option in total eliminating of fossil based thermal emissions in the glass industry.

Increasing the percentage of culets of recycled glass will be one of the most feasible options in minimizing the IPPU emissions in the glass industry while reducing the industry energy use emissions due to minimisation of virgin raw material use in the industry. In addition to the GHG reduction it will contribute to the natural resource conservation as well as virgin raw material mining and processing related emissions as well.

According to the position paper published by the "Glass industry Alliance Europe" (Ref: https://www.glassallianceeurope.eu/) "by recycling 74% of the bottles and jars put on the EU market, the glass industry saves about 9 million tonnes of CO2 every year and is at the forefront of the circular economy since decades".

As circular economy will play a major role in national sustainable economy as well as in national climate mitigation and waste management drives the use of used glass in glass industry is highly recommended.

However, it will be required to consider the feasibilities of this option with the national glass industry stakeholder organisation (Piramal Glass Company Limited).

Ceramic industry

According to the 2000 -2010, Ceramic industry data provided in TNC, 1% of the IPPU emissions are from the ceramic manufacturing (both ceramic tile and porcelain / Chinaware manufacturing sectors (figure 2.aa Page 7).

Calcite and dolomite, which are carbonate are the raw materials used in the ceramic industry which are relevant to the CO_2 emissions when subjected to the thermal curing process in the industry.

Application of cleaner production technologies will be the main option in minimizing the ceramic industry related IPPU emissions. Subsequent to the maximum effort in process efficiency improvement and minimizing the process-based emissions, remaining emission quantities are recommended to offset with national forestry development plan or "Carbon Capture and Storage" (CCS) strategy or "Carbon Capture, Utilization and storage" (CCUS) strategy appropriate to the industry and viable to the business operation.

As ceramic industry consumes substantial volumes of fossil-based energy sources in their kiln operations, there will be a very feasible opportunity use green Hydrogen as a mean of decarbonizing the ceramic industry. Some of the global ceramic industry (https://www.mykonosceramica.com/en/combustion-by-hydrogen-is-achieved-for-the-first-time-in-a-ceramic-kiln/) has taken initiatives towards this option.

Therefore initiatives on green Hydrogen opportunities as a ceramic industry will have decarbonizing the ceramic sector while higher opportunities to approach the global green ceramicware market.

Solvent use

According to the TNC, solvents are used for a variety of purposes including their use as a cleaning agent and in manufacturing surface coatings and dry-cleaning agent, tetrachloroethylene (C_2Cl_4). These are mainly sources of NMVOCs and it's amounting to about 4% of CO_2 out of the total IPPU emissions.

Use of solvents in industry are process specific and mitigation options are very limited. But adoption of Cleaner Production technologies is highly recommended in minimizing solvent based emissions.

Bread manufacturing industry

Bread manufacturing process is contributing to the GHG emissions in two modes; Baking process energy use emissions and fermentation process.

By fuel switching and use of electrical energy with minimized / zero grid emission factor will lead to minimize the emissions from bakery industry.

As fermentation process is a biological process and the emissions are bio carbon, it is proposed not to account the said emissions. As sub sector emissions are relatively very small it is recommended to not consider any specific mitigation measures other than application of Cleaner Production initiatives in emission reduction and other economic benefits.

GHG Emissions from the Industry IPPU Sector in the Mitigation (Net Zero) Scenario

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 3.24.

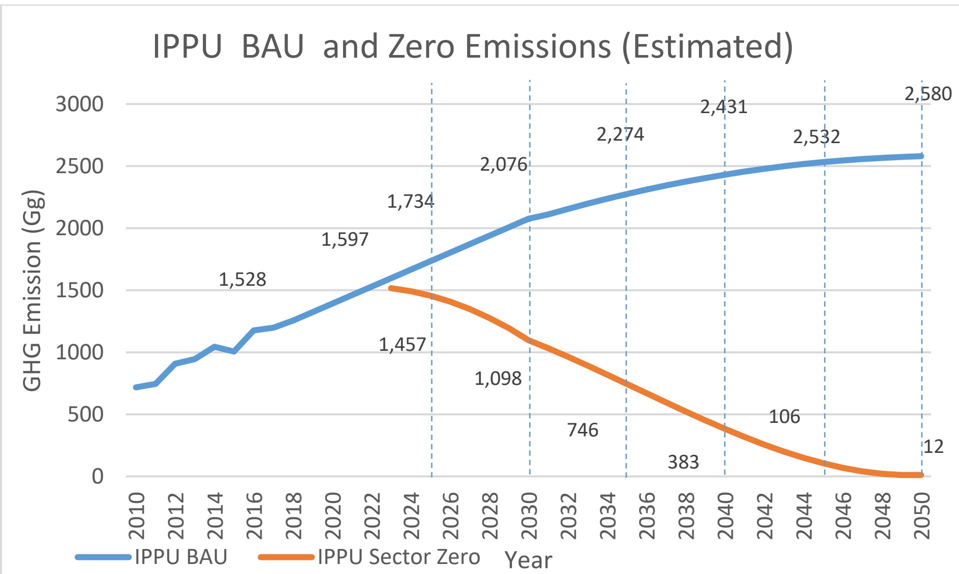


Figure 3.24 : Estimated GHG Emissions from the Industry (IPPU) Sector in the baseline and Mitigation scenarios

3.3.4 Waste Sector

The timeline for the Net Zero Carbon – 2050 was decided considering the development, socioeconomic, and demographic factors. The mitigation actions are spaced into 5 years to execute chronologically 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 are,

- Daily Cover for Open dumps
- Syngas recovery from open dumps
- Vertical Subsurface flow constructed wetlands (VSSFCW)
- MSW Growth reduction to 50%.
- Mandating 3R practice.
- Electric vehicles for waste collection.
- Waste to energy plants for non-biodegradable waste that remains after all other options.
- Sanitary landfill
- Circular Economy for Redesign, Reuse and Rethink

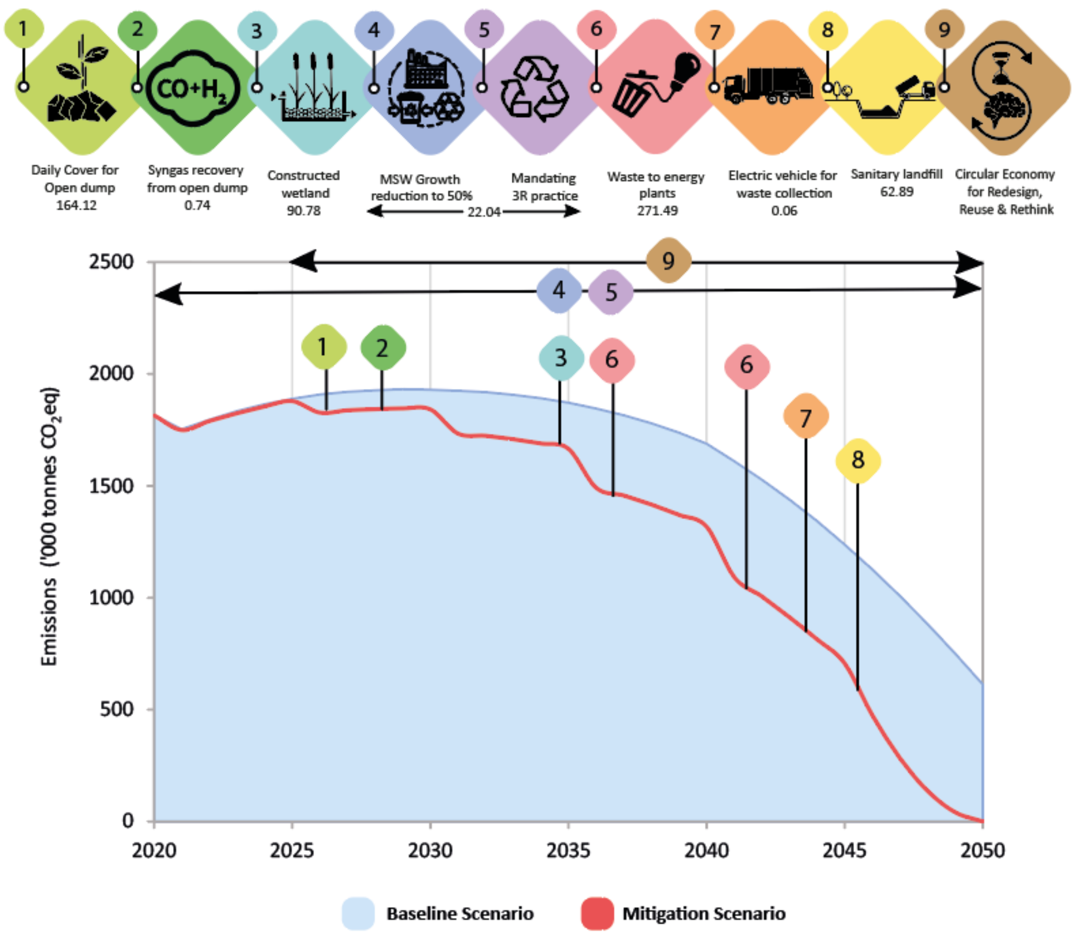


Figure 3.25 : Net zero scenarios with mitigation measures

Prediction Model

This analysis and prediction model is based on demographic and socioeconomic factors such as population and GDP. Waste generation analysis was done using time series data of solid waste generated quantities. The time series analysis model is used to estimate greenhouse gas emissions for the waste sector. Model performance was tested using root mean square error. The results show that forecasting models have a good potential to estimate the national greenhouse gas emission for the waste sector within a reasonable error.

Data gathered from the report of Third National Communication of Climate Change in Sri Lanka (MoE, 2022) 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 where they show a steady increase in every section indicating mitigation measures are vital to reduce the GHG emissions in every aspect.

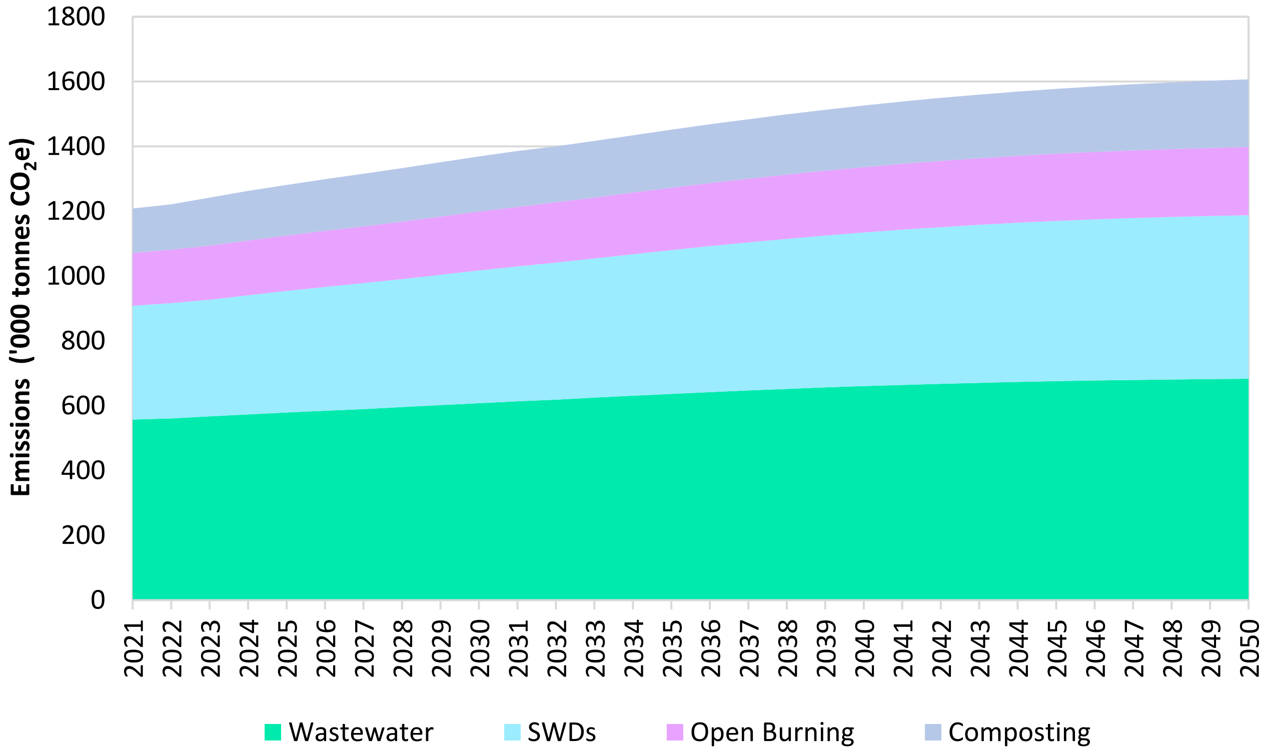


Figure 3.26 : GHG emission prediction from 2021 to 2050

3.3.5 Agriculture Sector

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

a. Reduction of methane and nitrous oxide generation in paddy fields by removal of straw from paddy fields 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 animal comfort improvement
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 referring to the World Bank and CIAT report (2015), "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.

In order to minimize the baseline data variability, over the predictions, only unconditional targets given in NDC Sri Lanka 2030 were extrapolated using a second order polynomial up to the year 2050 Figure 3.15.

Emission reduction from the extended NDC 2030 scenario

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.

When the NDC conditional target actions were considered, applicability of these with respect to the field level extension, present economic situation of the country and other facilities, is beyond control and therefore, it was decided to use the Unconditional target, which predicts up to 30 % reduction from the baseline data when developing the NDC 2030 extended scenario up to 2050 for the agriculture sector.

Emission reduction from mitigation scenario

Scenario comparison

As shown in the Figure 3.27, mitigation scenario is capable of reducing GHG emissions by 61% compared to the baseline scenario.

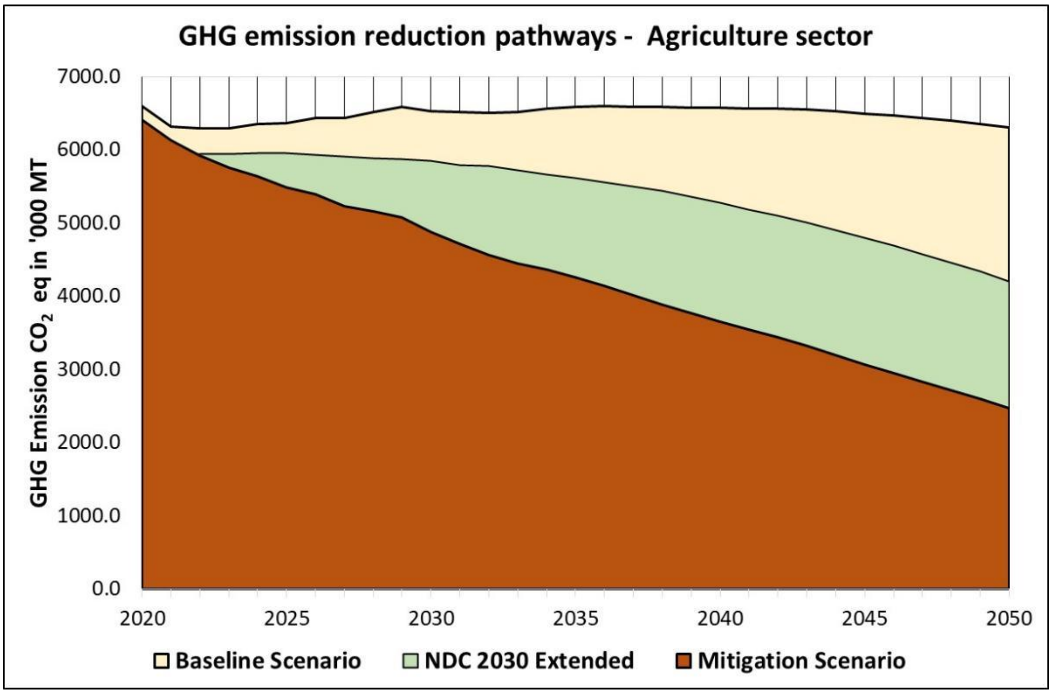


Figure 3.27 : Best case scenario for the agriculture sector

When the following strategies are adopted, GHG emissions could be reduced as illustrated in Figure 3.28

1. Reduce methane emission from paddy fields by removing rice straws and through good management practices
2. Use alternatives to Chemical fertilizer for reducing N_2O emission.
3. Reduce methane emission from livestock by improving feed quality and animal comfort.
4. Reduce N_2O emission in soils due to microbial activities.

GHG emission reduction by strategies

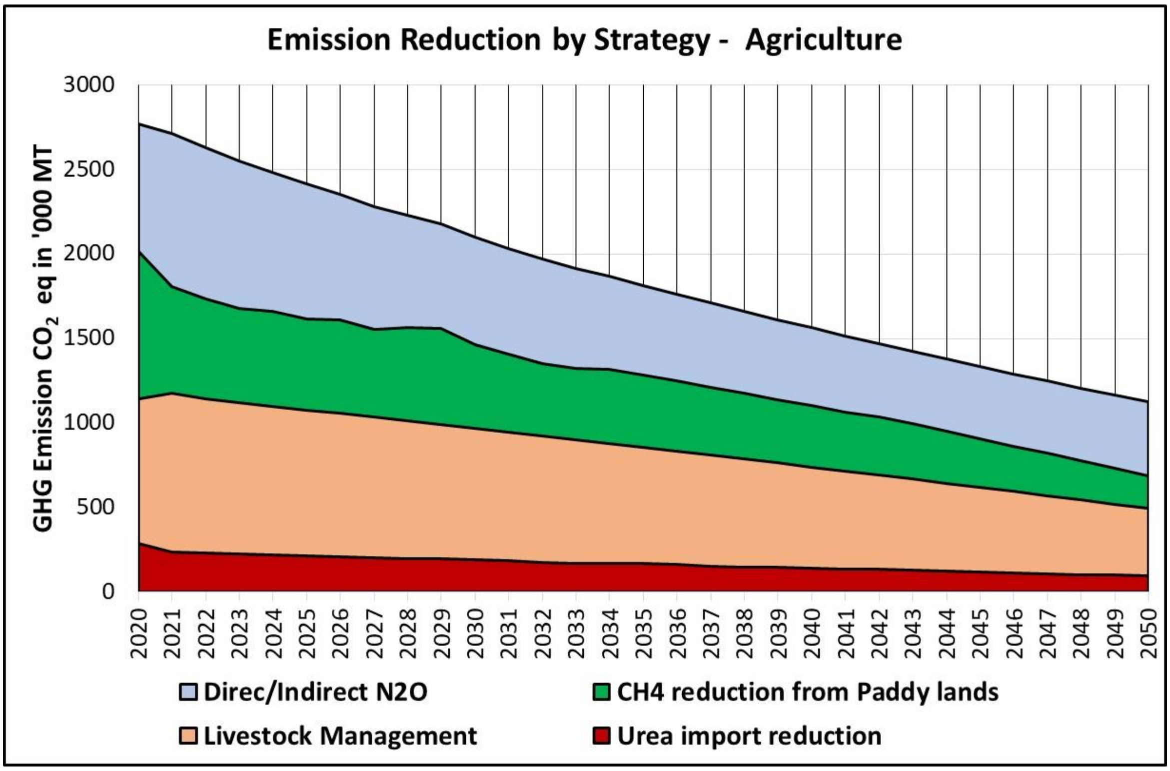


Figure 3.28 : GHG reduction by four strategies

Table 3.4: Emission reduction by different scenarios adopted

Year	Emission reduction in CO_2 eq '000 Mt			Percent emission reduction compared to baseline	
	Baseline scenario	NDC 2030 scenario extended	Improved version	NDC 2030 scenario extended	Improved version
2025 - 2030	35,430	39,361	30,625	9%	20%
2031 - 2035	28,600	33,219	24,405	13%	32%
2036 – 2040	27,140	33,479	23,456	18%	41%
2041 – 2045	25,010	33,248	22,226	23%	49%
2046 - 2050	22,270	32,442	20,667	30%	58%

As shown in the Figure 3.28, model developed for the C Net Zero 2050 was able to reduce 61.1 % GHG emissions from the year 2025 (6374.4 CO_2e in '000 tonnes to 2476.7 CO_2e in '000 tonnes) to the year 2050. compared to the baseline scenario developed for the study and NDC unconditional targets projection, which was able to reduce 29.5 % from the year 2025 (5957.6 CO_2e in '000 tonnes to 4200 CO_2e in '000 tonnes) to the year 2050. This clearly shows the limitations in the agriculture sector to reduce GHG emissions, where basically land and field level extension services are limiting.

GHG emissions from postharvest management practices are also considered in the NDC Sri Lanka 2030 and therefore, C net zero 2050 model was also able to address emissions coming from the postharvest management practices. Further to that, it is proposed to introduce new technologies, like solar and other renewable energy sources to minimize GHG emissions from the agriculture sector.

3.3.6 Forestry Sector

The Mitigation Scenario refers to the scenario with 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 planned to be adopted. In the case of the Forestry sector, this scenario was developed using the following assumptions:

A. Forest cover includes natural forests, forest plantations and rubber plantations according to the definition of forests by FAO.
B. The deforestation rate will be 5000 ha/yr from 2021-2030 as per the Revised Nationally Determined Contributions (NDCs) (Ministry of Environment, 2021) and will be reduced to 1000 ha from 2031-2035; 500 ha from 2036-2040; 100 ha from 2041-2045 and then 0 ha from 2046-2050
C. The new plantings will be 18,050 ha from 2021-2030 according to the Ministry of Environment, (Revised NDC, 2021-2030, Ministry of Environment, 2021) 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. In home gardens, the annual loss of 0.3% will be stopped while the annual increase of 1% will remain.
F. In the coconut plantations, the annual loss of 616 ha will be stopped, while the annual increase will be 20,000 ha
G. In the tea plantations, annual increase was taken as 1800 ha; 40 trees/ha is the density of shade trees
H. 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.
I. The loss of mangrove extent is 0.5% /yr will be stopped and there will be 200 ha added annually

Following Reference values were taken in the calculations:

Emission factors

a) 150 tons/ha in deforestation and replanting of new forests
b) 100 tons/ha in establishment of new coconuts and tea plantations; due to the scattered nature of plantings this was not considered in mangroves and urban tree cover

Carbon sequestration factors

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: 9 tonnes/ha/ year; appropriate rates of carbon sequestration (2-9 tons/ha/year) were 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;
e) Carbon sequestration rate of mangroves – 24.76 tonnes/ha/year.

Table 4 in Annexure 3 shows the projected extents of forests, trees outside forests and mangroves (ha) from 2025-2050 in the Net Zero Scenario, and Table 5 in Annexure 3 shows the corresponding estimated annual Carbon sequestration quantities during the period 2025 to 2050. The Net Carbon Sequestration in Forests, Trees Outside Forests and Mangroves in the Net Zero Scenario (tonnes /year) is given in Figure 3.29

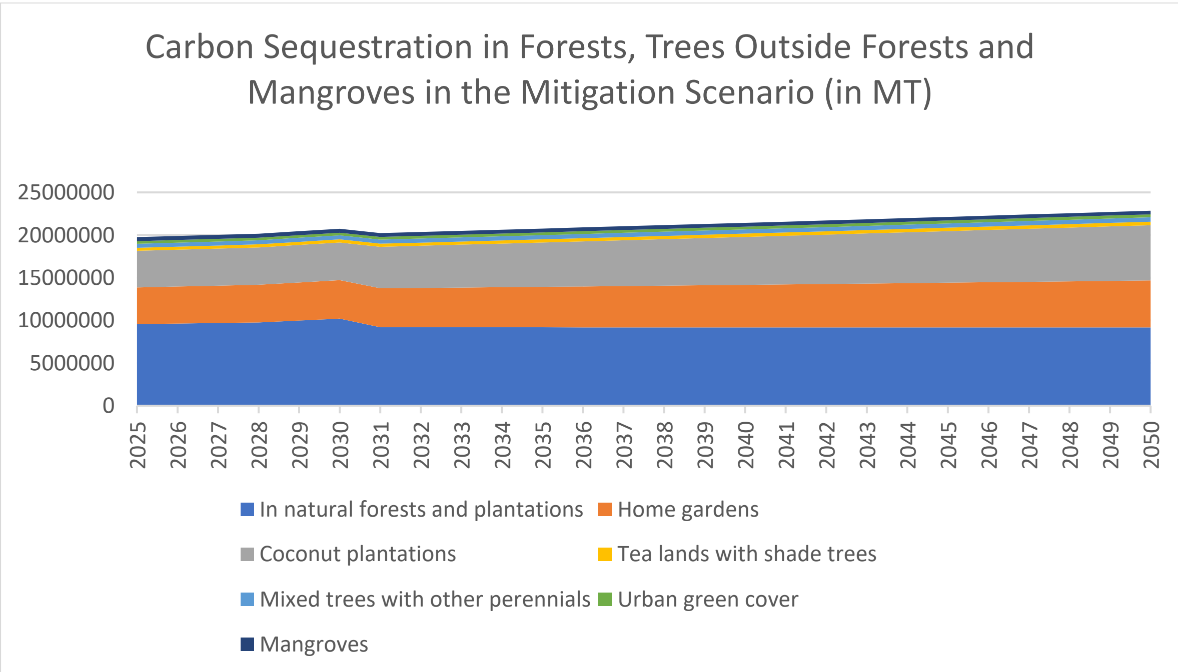


Figure 3.29: Net Carbon Sequestration in Forests, Trees Outside Forests and Mangroves in the Net Zero Scenario (tonnes/ha/yr)

At the same time, the GHG emissions will be caused by the loss of forest cover, Trees outside the Forests and mangroves. Table 6 in Annexure 3 shows the total GHG emissions from the forestry sector including loss of forests and trees outside forests in the Net Zero Scenario from 2025-2050. Please note that it is assumed that there would be no loss in mangroves and urban trees and avenue plants in the Net Zero scenario.

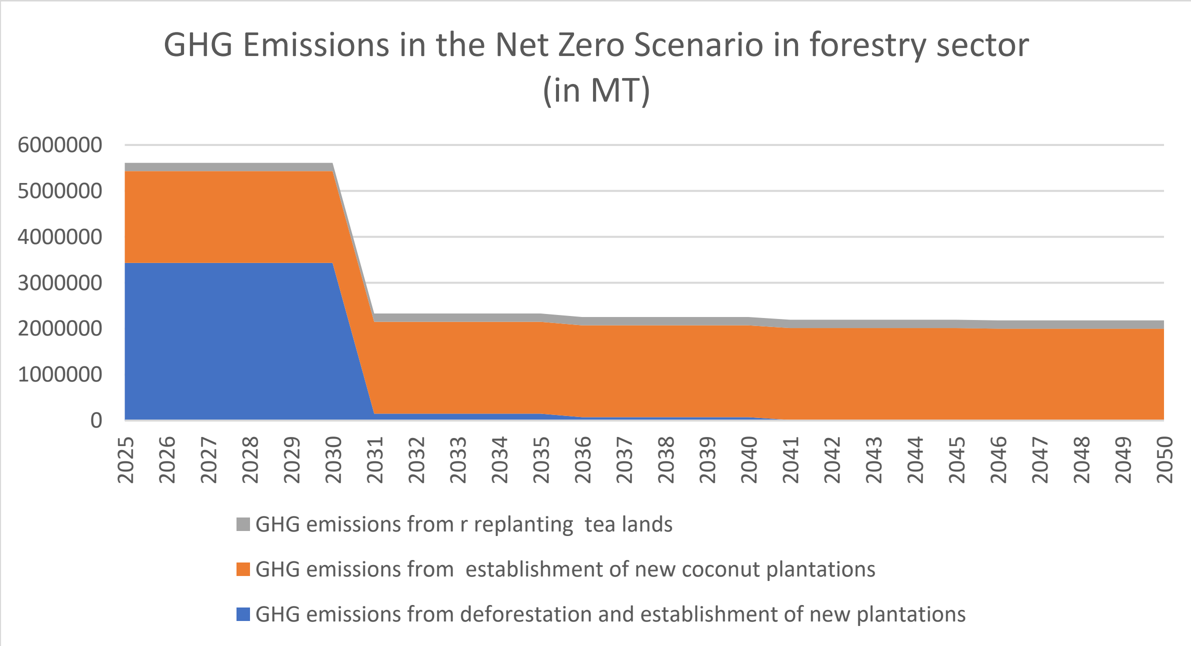


Figure 3.30 : The total GHG emissions from the forestry sector including forests and trees outside forests in the Net Zero Scenario from 2025-2050.(000' Tonnes/yr)

3.3.7 Overall Net Emissions in the Mitigation Scenario

Considering the GHG emissions and sequestration projections as modelled for the period 2025 to 2050 for the six sectors under the selected development, as described in the sections 3.3.1 to 3.3.6 of this report, the Best-Case emission situation that can be expected in the Mitigation Scenario is shown in Figure 3.31, and the emission quantities are given in Table 3.4. The net emission levels (total emissions - total sequestrations) are shown as a white line graph in Figure 3.31, and this shows a decreasing trend throughout the period 2025 to 2050. As seen in Figure 3.31.and Table 3.5, the Mitigation Scenario would result in a net annual emission quantity 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 the section 4.5 of this report. It is however imperative that the policy background is in place, and 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.

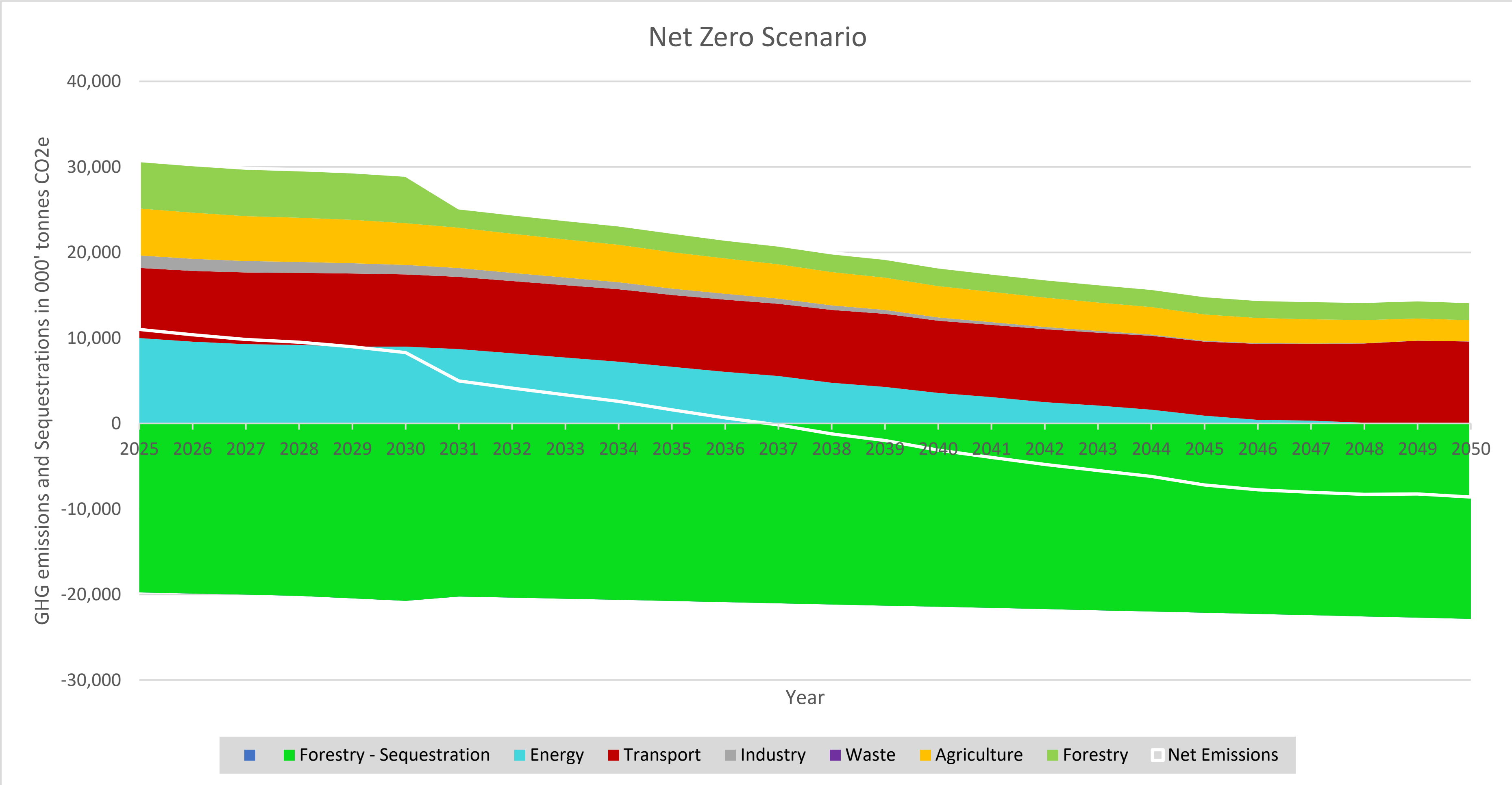


Figure 3.31 : Overall Net Emissions in the Mitigation Scenario

Table 3.5: Total Emissions in million MTCO2eq 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	1.91	1.88	1.91	1.95	1.98	2.01	1.94	1.96	1.98	2.00	2.02	1.89	1.91	1.92	1.92	1.93	1.80	1.81	1.82	1.82	1.82	1.70	1.63	1.60	1.63	1.72
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 – The emission in 2025 as of the base line scenario is 1.92 million tonnes CO_2eq per year and reduced by 0.01 million tonnes CO_2eq per year due to the mitigatory strategy "MSW Growth reduction to 50% and Mandating 3R practice is currently under practice".*

***Note 2 – The GHG reduction of 0.61 million tonnes CO_2eq by 2050 is from the proposed mitigatory actions, whereas the rest (1.72 million tonnes CO_2eq by 2050) is reduced from the modified actions proposed by the NDC 2030*

SECTION 4 : PROPOSED CARBON NET ZERO FRAMEWORK FOR 2050

4.1 Vision – "A Carbon Neutral, Prosperous Sri Lanka"

4.2 Vision Statement

According to the U.N. Climate Science Panel, man-made carbon dioxide emissions need to reach "net zero" by mid-century to give the world a good chance of limiting warming to 1.5^0C and avoiding the worst impacts of climate change. Transitioning to a carbon net-zero world is one of the greatest challenges the humankind has faced. Sri Lanka, being a developing country, cannot compromise economic and social development to achieve carbon net zero status. This is an effort to ensure a prosperous and secure optimal solution for the country, which is not contributing to the global consequences of climate change caused by anthropogenic GHG emissions.

4.3 Targets for Reduction of Emissions

As discussed in Section 3 of this report, the GHG emissions for each sector under the Baseline Scenario, which is taken as the situation where the current trends would continue up to the year 2025, and the unconditional actions identified in the updated NDC Report (MoE, 2021a) i.e. those that do not need external support, are implemented up to 2030 and beyond, the GHG emissions due to the six identified sectors would result in a net emission quantity of 23.62 Mt/year, as seen in the cumulative graph in Fig 3.21.

The targets for achieving Net Zero were set by the sector experts for each sector, in consultation with the sector stakeholders, considering the technically and administratively feasible actions to mitigate emissions in each sector, provided funds, infrastructure and technological resources were not a constraint for implementation, over the period 2025 to 2050. The emissions and sequestration values for the sectors were calculated using the models described in section 3, and the cumulative emission scenario is shown in Fig 3.30.

The sector-wise target setting is described in this section.

4.3.1 <u>Energy Sector</u>

The vision for the energy sector is to achieve carbon neutrality in the energy sector itself by complete transition of all the energy value chains to net zero by 2050. Therefore, the Target set for the Energy Sector is to reduce the predicted quantity of GHG Emission of 13.246 million tonnes/year of CO_2e to zero by the year 2050. To achieve this overall target, each energy source will be set the 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

	Target for Emission Reduction by 2050 (million tonnes CO_2e per year)	Percentage Emission Reduction
Electricity	10.413	100%
Domestic and Commercial Energy	5.494	100%
Total Energy Sector (Excluding fuel used in Transport and Industry IPPU)	15.907	100%

4.3.2 Transport Sector

Transport sector mitigation strategies aims to reduce the emission level by 50% by the year 2050. This is the prudent estimate considering the projects that can be implemented during the time period.

The prediction of emissions for the Baseline Scenario is 19 million tonnes/year in 2050. Thus, the target for emission reduction in the transport sector is 8.4 million tonnes/year in 2050 as described in the section 4.5.2

4.3.3 Industry Sector

Industry sector emissions are in two sources; the industry energy use (both electrical energy and thermal energy) emissions and IPPUs.

Achieving 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 is already addressed under energy sector.

Considering the highest energy value of hydrogen (150 MJ/ kg) and other multiple opportunities offered with green Hydrogen, it is highly recommended to maximize the renewable energy capacity in national grid. With the saturated grid renewable energy more green Hydrogen generation opportunities will be opened. Accordingly, the green hydrogen will provide following zero carbon opportunities;

- Buffering the grid qualities at renewable energy intermittencies,
- Use of green hydrogen as an energy storage to produce electrical energy during power deficiencies in nation grid with fuel cell technologies, and gas turbine-based power gyration,
- Use of green hydrogen as a source of thermal energy in industry thermal energy applications,

- Use of green hydrogen as a fuel in transport industry,
- Use of green hydrogen to produce green ammonia and use as a marine fuel and develop national green nitrogen fertilizer industry.

In addition to above industry energy use emissions national IPPU emissions are relative low in quantity.

Strategies recommended to the zeroing of emissions in IPPUs are discussed in previous chapters.

IPPU sub sector emission zeroing scenario are depicted as below;

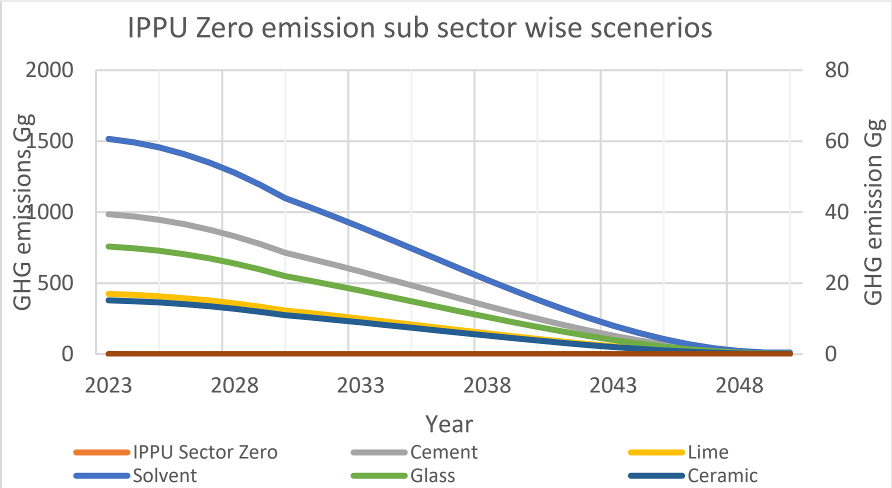


Figure 4.1 : IPPU Zero Emission Sub Sector wise Scenarios

This will be a reduction of 2,568,000 tonnes in 2050, and the estimated reduction is 99.5%

4.3.4 <u>Waste Sector</u>

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.

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

Strategy	Baseline CO_2e Emissions 2050 (thousand tonnes CO_2eq per year)	Target for Emission Reduction by 2050 (thousand tonnes CO_2eq 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%

Strategy	Baseline CO_2e Emissions 2050 (thousand tonnes CO_2eq per year)	Target for Emission Reduction by 2050 (thousand tonnes CO_2eq per year)	Percentage Emission Reduction
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	612.11	26.24%

4.3.5 Agriculture Sector

In order to reduce the greenhouse effect from the agriculture sector, appropriate management practices must be introduced to minimize CO_2, CH_4 and NO_2 emissions. Further to that Land Surface Albino in agricultural lands should be minimized to lower the surface reflectivity and suitable alternative measures must be introduced to minimize CO_2 emissions from agricultural fieldsThe main emphasis in agricultural sector should be given to GHG emission reduction from Paddy fields, livestock and cultivated area of organic soils in the order of importance.

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 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
Paddy fields (due to methane emissions)	1830	1145	62 %
Reduce N2O by reducing urea imports	244	150	61 %

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
Direct/Indirect N2O reduction	2788	1664	60 %
Methane – Livestock management (neat cattle local, imported, Goats and Sheep)	1251	758	61 %
Total	6113	3717	61 %

4.3.6 <u>Forestry Sector</u>

According to the NDC in forestry, it was stated that the rate of deforestation will be 5000 ha/yr. In the present project to Develop the 2050 Carbon Net Zero Road Map and Strategic Plan for Sri Lanka, it is expected that the rate of deforestation will be further reduced from 5000 to 0 from 2031 to 2050. Accordingly, from the Net Zero Road Map actions and Strategies the target is to reduce 750,000 tonnes per year CO_2 during the period 2025-2050 from deforestation in the baseline scenario.

4.4 Targets for Increased sequestration

4.4.1 <u>Agriculture Sector</u>

The concept of evergreen Agro ecosystems is of multipurpose. Initially based on research conducted in DOA, a green hedge was introduced as a part of agro-forestry system to control soil erosion, enhance soil fertility and to create a micro-climate favorable for crop growth[1] (Dharmasena 1994) This is an alternative to chemical fertilizer as N, P and K are added into the soil by pruning proposed green hedges. Carbon sequestration can be enhanced through this concept especially for croplands with extended fallow periods.

An example for Evergreen Agro-ecosystem Concept is shown in the Fig. 4.2

[1] Dharmasena,P.B., 1994. Conservation farming practices for small reservoir watersheds: a case study from Sri Lanka. Agro-forestry Systems, Kluwer Academic Publishers, Netherlands. 28:203-212

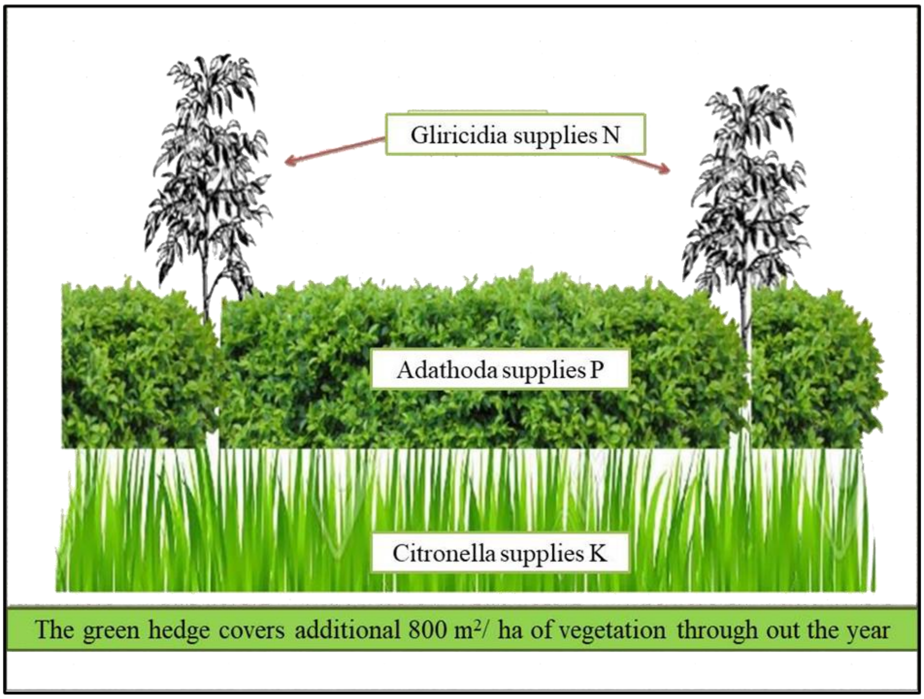


Figure 4.2: Evergreen hedge suitable for paddy fields and rainfed uplands

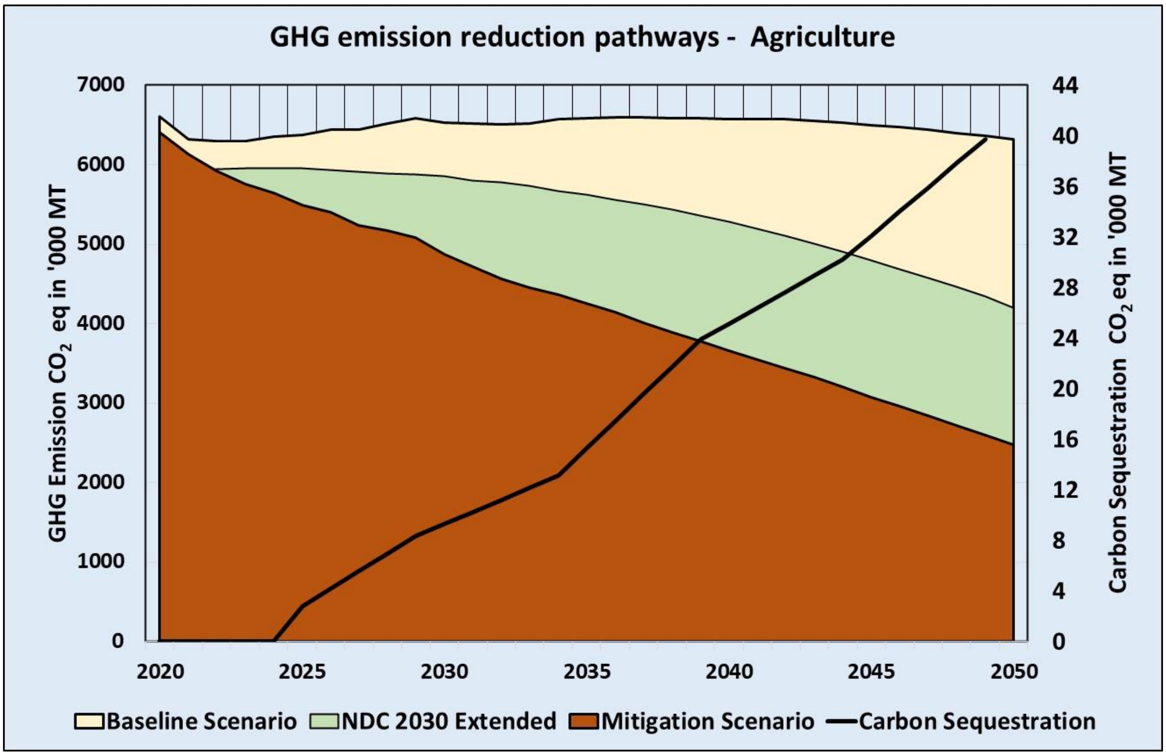


Figure 4.3: GHG emission reduction pathways and Carbon Sequestration in thousand metric tons.

It was observed that introducing evergreen concept in paddy lands and upland rainfed crops covers a very small area and therefore, secondary axis was used to plot the values in the pathways described in the Figure 4.3

4.4.2 Forestry Sector

According to the updated NDC (2021-2030), 18,000 ha 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 Net Zero Road Map and Strategic Plan, the Forest Department is hoping to reforest/afforest 200,000 ha of land by 2050. This land is included in the land under the category 'Other State Forests' which was vested under the management of Forest Department in the 5/2001 Circular but was cancelled subsequently and these were vested under the custody of Divisional Administrations. However, out of the 500,000 ha, 200,000 ha had been released to the Forest Department for restoration/ reforestation/ afforestation. It is also hoped to increase the contribution of trees outside forests to the GHG mitigation scenario. These include homegardens, coconut plantations, shade trees in the tea plantations, urban trees and avenue trees, 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. Tables 5 and 6 in Annexure 3 show the net carbon sequestration of forests, trees outside forests and mangroves in Baseline Scenario and Net Zero Scenarios respectively.

Table 4.4: Targets for Land Cover Increasement in Forestry Sector in 2050

Description	Estimated Baseline Area in 2050 (ha per year)	Target for Increased Area by 2050 (ha per year)	Percentage 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%

There is no increase in land cover for shade trees of tea plantation and mixed trees with other perennials.

Table 4.5: Targets for Increased Sequestration in Forestry Sector in 2050

Description	Estimated Baseline Sequestrations in 2050 (tonnes CO2e per year)	Target for Increased Sequestrations by 2050 (tonnes CO_2e per year)	Percentage Sequestration Increasement 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 sequestations for mixed trees with other perennials while reduction of sequestrations in shade trees of tea plantation.

4.4.3 Waste Sector

Use of Biochar as the Daily Cover for Open dumps

Soil cover is a conventional barrier to mitigate landfill gas emissions from municipal solid waste (MSW) landfills. Methane is a major component of landfill gas, and it is also a more harmful greenhouse gas than carbon dioxide. A daily cover combined with biochar produced from the MSW in the dumpsite can be used to trap GHG emissions by a considerable amount. According to a study carried out by Abraham and Xiao in 2019, 10% of GHG 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. The daily cover absorption showed an absorption of 164,115.9493 CO_2e tonnes by 2050. This measure can be implemented as early as 2026.

Vertical Subsurface flow constructed wetland (VSSFCW)

According to a study conducted in China in 2011 by Pan et.al, 50% of GHG can be reduced using the VSSFCW rather than the conventional methods. The VSSFCW with an area of 1000m^2 is capable of reducing the 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 90,781.26637 CO_2eq tonnes by 2050.

Table 4.6: Sequestration by Waste

	Target for Emission Reduction (Sequestration) by 2050 (tonnes CO_2e per year)
Use of Biochar as the Daily Cover for Open dumps	164,115.95
Vertical Subsurface flow constructed wetland (VSSFCW)	90,781.26

4.5 Feasible Strategies and Mitigation Actions for Achieving Targets

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 provided by:

- Providing strategic direction, oversight, support and sufficient resources to set and achieve targets,
- Incorporating net zero targets into core governance documented information (e.g. national policies, action plans, regulations etc.,),
- Disclosing stakeholder need information and records on climate-related issues, if appropriate to the country and net zero emission targets,
- Publicly committing to achieve 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 further action needed.

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

4.5.1 Energy Sector

Aligned with the national energy policy, it is required to have multiprong approaches in the energy sector to achieve carbon net zero by 2050. The broad strategies are detailed below.

4.5.1.1 Gradual decommissioning of the existing thermal power plants which depends on imported fossil fuel and enhance self-reliance.

It relates to the necessity of a rapid decline in the share of fossil energy in Sri Lanka's primary energy mix. For that decommissioning of existing thermal electricity generation infrastructures, particularly coal power plants and other petroleum-based power plants. It is necessary to continue the government policy on not to construct any new coal power plant in the future. Furthermore, a rapid increase in the share of renewable energy in the electricity generation mix would be a key component in meeting the increasing electricity demand. As per the government policy, it is expected to achieve 70% of electric energy from renewables by 2030. Increasing RE capacity also identified as one of the NDCs in power sector. This includes predominantly solar and wind. Other renewable energy resources have to be exploited based on a priority order arrived at, considering economics, technology and quality of each resource. By considering the energy security, network stability and reliability, it is suggested to integrate variable renewable energy (VRE) with energy storages such as battery storages and pump hydro plants. Therefore, 70% RE share has been assumed to be maintained in the power sector with other carbon net zero power generation options.

4.5.1.2 Development of Nuclear energy resources to the optimum level with sufficient environmental safeguards, by encouraging market demand for such resources

In the absence of fossil, there will not be any other base load zero-carbon technology apart from nuclear energy. Nuclear energy has been very important from the perspective of the country's energy security and has always been an important pillar of future Sri Lanka's energy policy. However, progress on this technology in terms of its penetration into the grid has always lagged. Under net zero carbon scenarios, nuclear-based electricity generation would receive a significant push. The LTGEP proposes nuclear power generation as a scenario. In there, the first nuclear power plant has been proposed in 2041. However, in order to reduce the contribution of fossil fuels and decarbonize the power sector, rapid development of nuclear energy is recognised as critical. As per the draft "Roadmap to establishing a Safe, Secure, Affordable and Reliable Nuclear Power Programme in Sri Lanka" the following nuclear power generation programme is identified in Sri Lanka.

a) Approximately 300 MWe x 02 Units as per the present national grid
b) 1000 -1200 MWe x 02 units (with HVDC interconnection)

However, under the expedited nuclear power generation scenario, it is expected that the share of nuclear energy in Sri Lanka's electricity generation would increase to 7% by 2035 and increase it to about 20% in 2044.

4.5.1.3 Promote Regional Power Grid Connectivity and Cross-Border Electricity Trade

India and Sri Lanka signed a Memorandum of Understanding (MOU) in 2010 to conduct a feasibility study for the interconnection of the electricity grids of the two countries. This feasibility study was carried out jointly by CEB and Power Grid Corporation of India Limited (POWERGRID). This study proposed an interconnection through 2x500 MW Madurai-New to New Habarana along with 500 MW terminals at both ends as the preferred option in stage I. Therefore, LTGEP proposes the first 500 MW HVDC interconnection in 2034 as a scenario. This can be expanded by adding additional 500 MW HVDC connecting in 2037 totaling 1000 MW regional grid connectivity. This will also facilitate the rapid development of renewable energy and nuclear energy and achieve net zero carbon emission by 2050. This will open the cross-border electricity trading as well.

4.5.1.4 Improving Energy Efficiency and Conversion

Energy efficiency is the practice of using less energy to accomplish the same task or simply eliminating energy waste (Diawuo et al., 2020, Efficiency., 2021, Patterson, 1996). Energy efficiency has a variety of associated benefits including greenhouse gas emission reduction, demand for energy imports reduction, and household and economy-wide level cost lowering. Comparatively, the use of energy efficiency is found to be the cheapest approach to achieving these objectives amongst the available options presently. As per the countries' declared NDCs, energy efficiency, conservation and Demand Side Management (DSM) is also considered one of the potential areas of reducing electricity demand and thus reducing the emissions in the power sector. Programs such as phasing out of the incandescent bulb and introducing energy efficient equipment expect to save 2,603 GWh and 5,189 GWh energy respectively and thus 1,848 Gg and 3,684 Gg CO_2 emission reduction respectively by 2030 (SLSEA). Minimum energy performance standards for LEDs and energy labelling for air conditioners, personal computers, refrigerators, ceiling fans, linear fluorescent lamps/ballasts and induction motors has to be enforced by 2025.

A program should be set up to increase the penetration of efficient, low smoke, low soot biomass cook stoves for households and promote the use of processed, commercialized biomass based fuels in such stoves by making available them widely across the retail market.
These have been considered as a complementary strategy to reduce GHG emission in the energy sector.

4.5.1.5 Energy Transition by Enabling the Continued use of Flexible and Secure Thermal Energy while Reducing Negative Impact to the Environment

The technologies like hydrogen could play a central role in helping to reach net-zero emissions by 2050 by replacing fossil fuel base thermal energy generation by hydrogen based flexible thermal energy. As a complement to other technologies, including renewable powered hydrogen (green hydrogen) has the potential to decarbonize industries, heavy-duty mobility (on and off-road), maritime shipping, and aviation, as well as to support flexible power generation (among other applications). However, before proceeding, it is crucial to acknowledge that no proper assessment of the hydrogen industry in the country has been conducted yet. Therefore, a detailed feasibility study must be undertaken immediately to lay the groundwork for its successful implementation. These have been considered as complementary strategies to reduce GHG emission in the energy sector. Possibility of adopting green hydrogen in Sri Lanka have to be exploited considering economics, technology maturity and adoptability.

Based on above strategies, following mitigation actions are proposed, along the timeline from 2025 to 2050, as shown in Tables 4.9, 4.10 and 4.11, to reduce GHG emissions in the energy sector.

Table 4.7: Proposed renewable energy capacity additions

Year	Renewable Energy additions (MW)							
					Pathway 1: With Nuclear		Pathway 2: Without Nuclear	
	Major Hydro	Pumped Storage	Mini Hydro	Biomass	Wind	Solar	Wind	Solar
2025			25	20	200	505	200	500
2026			25	20	290	500	290	500
2027			25	20	250	500	250	500
2028			25	20	200	520	200	520
2029		350	25	20	250	540	250	540
2030		350	10	20	200	450	200	450
2031		350	10	20	200	450	200	450
2032		250	10	20	150	450	250	550

2033			10	20	150	500	250	650
2034			10	20	150	510	250	850
2035			10	10	150	510	250	850
2036			10	10	150	520	750	850
2037			10	10	150	520	250	850
2038			10	10	150	530	250	1000
2039			10	10	150	530	650	1000
2040				10	150	550	150	1000
2041				20	150	550	150	1000
2042				20	200	570	1200	1000
2043				20	200	570	200	850
2044				30	200	570	200	850
2045				30	200	570	1200	850
2046				30	200	590	200	650
2047				30	200	590	1000	650
2048				30	200	620	200	650
2049				30	300	650	1000	650
2050				30	400	700	400	700

Expected thermal power plant additions (as per LTGEP 2023-2042) and proposed decommissions of thermal power plants to support the GHG emission reduction in the power sector is shown in Table 4.10.

Table 4.8: Proposed additions and decommissions of thermal power plants

	Additions (MW)			Decommissions (MW)		
	Natural Gas	Diesel	Coal	Natural Gas	Diesel	Coal
2025	115				62.4	
2026	200				375	
2027	100					
2033	150			398	191.7	
2035					300	
2041						300
2044						600
2049				795		
2050				100		

The proposed Nuclear and HVDC Connection additions are shown in Table 4.11.

Table 4.9: Proposed Nuclear and HVDC Connection additions

Year	Pathway 1: Nuclear Additions (MW)	HVDC interconnection (MW)
2034		500
2035	600	
2040	1000	
2047		500

With the above actions, the energy mix in the electricity sector is shown in Figure 4.4 and 4.5 for Option 1 (with Nuclear PP) and Option 2 (without Nuclear PP) respectively.

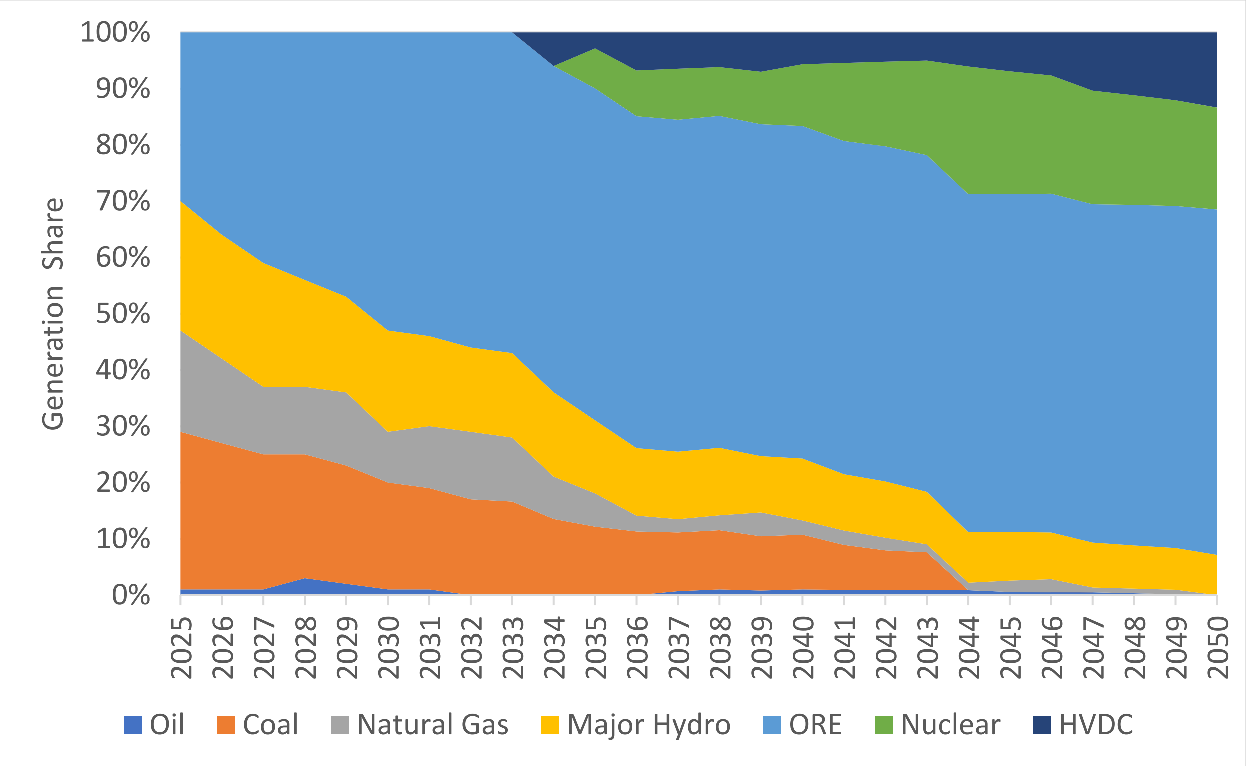


Figure 4.4 : Proposed Generation Share with Pathway 1(With Nuclear PP) to Reduce GHG Emissions in Power Sector

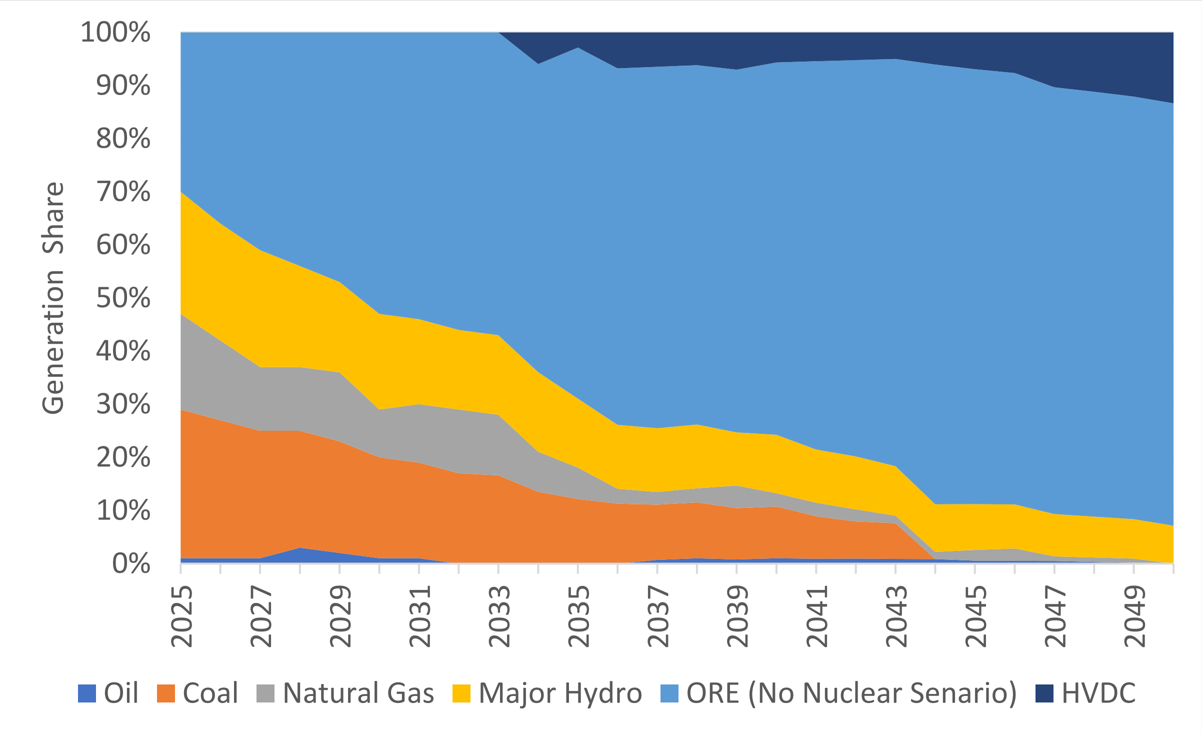


Figure 4.4: Proposed Generation Share with Pathway 2 (Without Nuclear PP) to Reduce GHG Emissions in Power Sector

By considering the trend of the past average capacity factors of the renewable energy, assuming an average capacity factor for renewable power plants between 13-18% during 2025-2050, the expected GHG emissions are estimated and shown in Figure 4.5.

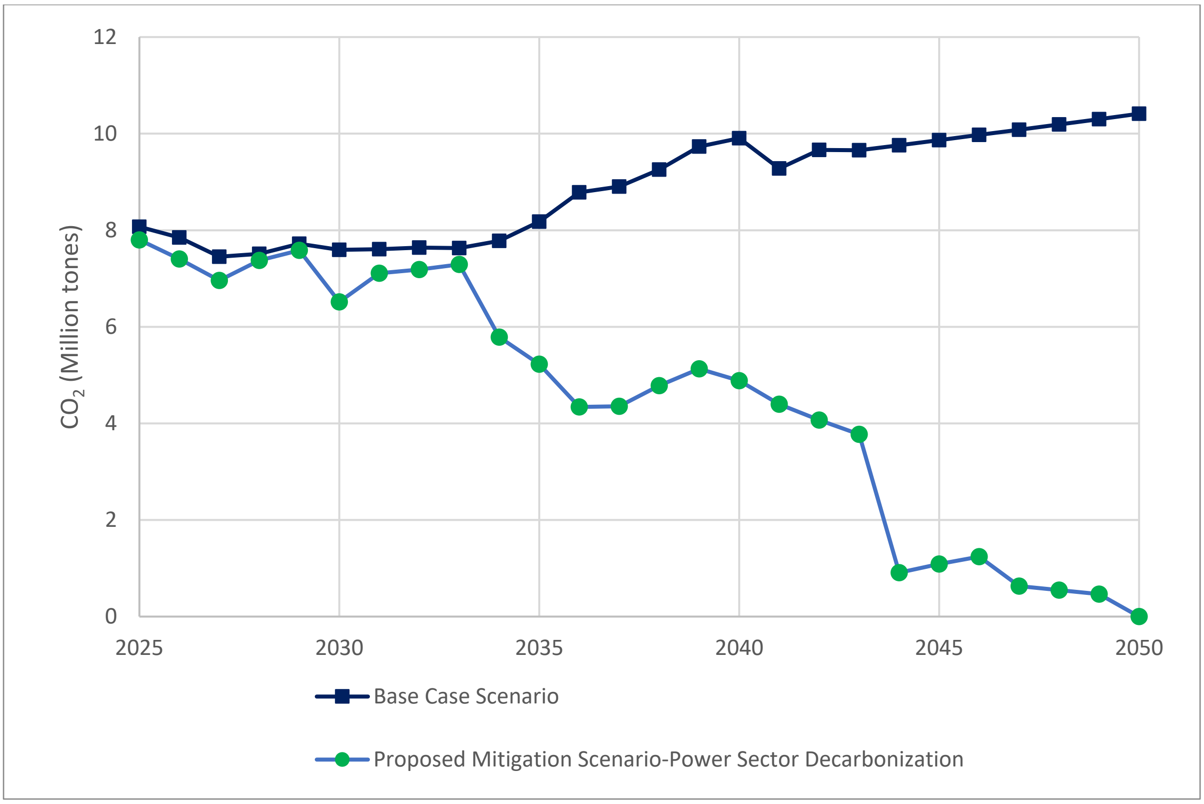


Figure 4.5 : Net Zero Scenario in the Power Sector

It is expected that there will be around 2,833 tonnes of CO_2 emissions in the energy sector by 2050, which can be brought to net zero by implementing the following further 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 households 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 above actions are implemented successfully, it is expected to achieve net zero in energy sector itself.

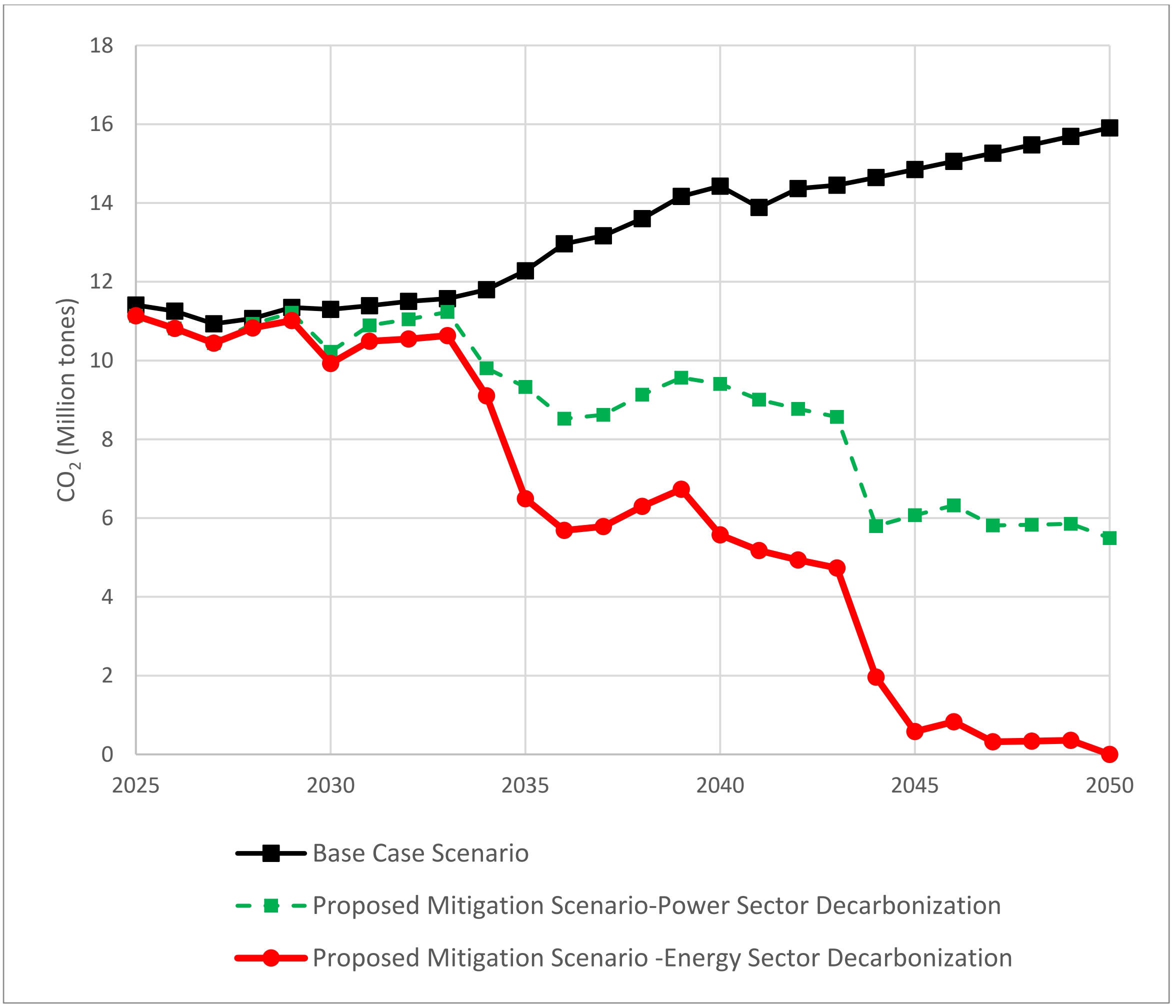


Figure 4.6 : Net Zero Scenario in the Energy Sector

4.5.2 <u>Transport Sector</u>

1. **Improve the pedestrian infrastructure on collector type roads in the country.**

Most of the roads especially B class and Provincial roads lack adequate pedestrian infrastructure to provide safe movement for pedestrians. As a result, most trips that are 'walkable' are diverted to motorized modes. It is evident from the trip characteristics of the Western Province where over 1.2 million trips per day are less than 2 km (JICA, 2014). According to RDA (2020) and Central Bank (2020), Sri Lanka has over 100,000 km of road network and more than 8000 km of B Class Roads and more than 20,000 km of C & D Class Roads.

It can be assumed that nearly 10,000 km of roads require improvements in pedestrian facilities. Moreover, this may include pedestrianization of certain areas such as markets, shopping areas, school zones prioritizing accessibility to pedestrian and discouraging motorized vehicles.

Around 50% of the motorized trips that are less than 2-3 km are expected to be diverted to walking trips as a result. This would result in reduction of CO_2 by 0.11-0.13 million tonnes per year during the analysis period.

Total number of motorized trips 2-3 km in Sri Lanka	5,000,000	
% Reduction in < 2km motorized trips to NMT modes	0.5	
Average distance of trip	2.0 km	
Passenger km per year	5,000,000	pass-km

per day

The amount of CO_2 emissions reduced due to this action is shown in Table 4.12.

Table 4.10: Amount of CO_2 emissions reduced by improving the pedestrian infrastructure on collector type roads

	Passenger km	Veh-km	kg per day
Motorcycle	1,250,000	1,250,000	75,000
Private vehicle	625,000	312,500	71,875
Three-wheeler	3,125,000	1,562,500	156,250
	5,000,000	3,125,000	303,125

At an overall average cost of Rs. 7-8 million per km including street furniture, crosswalks, street lighting where necessary, would cost around Rs. 70-80 billion.

The work can be commenced from around 2025 and completed during a 5 year period ending in 2030.

2. **Promoting cycling**

Promote cycling trips by providing network of cycle lanes in cities linking the major trip attractions and improving road infrastructure and traffic calming measures on local and collector type roads to allow cyclist to share the road with other motorized vehicle users in a safe manner

It is assumed a similar number of motorized trips will divert to cycling and the average trip distance would be around 5-6 km effectively doubling the CO_2 savings calculated for pedestrian infrastructure improvement.

Therefore, the CO_2 savings per annum from cycling infrastructure improvement is approx. 0.25-0.3 million kg per year during the analysis period.

Cost of cycling infrastructure improvement would vary depending in land acquisition requirements, existing carriageway characteristics etc. This would vary from fully separated bicycle lane on major roads as well as cycle lane marked on minor roads including other required lane markings and signage.

Around Rs. 100-150 billion for the project to cover the entire country (XU and Mayuga, 2022). The project could commence around 2050 and be completed over 10-year period.

3. **Promoting remote working**

Nearly 20% of the trips in Western Province are Home-based work trips in Western Province according to the ComTrans study survey by JICA (2014).

Around 4 million similar work trips can be targeted to promote work from home or flexible hours schemes (reduced number of working days).

Assuming a reduction of 25% of working trips under this policy and an average trip length of 10 km the reduction is 10 million passenger-km per day.

This is equivalent to a reduction of 0.58 -0.7 million tonnes of CO_2 per year under the typical modal composition for work trips.

Table 4.11: Amount of CO_2 emissions reduced due to promoting remote working

Mode share of trips shifted to WFH		trip/day	km/day	CO_2 kg/day
PT	0.3*			
Private car	0.4	400,000	4,000,000	920,000
MC	0.15	150,000	1,500,000	69,000
Three-wheel	0.15	150,000	1,500,000	115,000
Total		**700,000**	**7,000,000**	**1,104,000**

* PT (Public Transport) trip reduction is not accounted for CO_2 reduction since those are scheduled services which will be in operation.

4. **Promoting e-commerce and e-learning**

Other type of trips such as shopping, banking, education trips to an extent will also be done using online modes with the advancement of e-commerce and e-learning technologies. There should be incentives for fulfill their needs using these tools and reduce the need to travel.

Around 5 million similar work trips can be targeted. Assuming a reduction of 20% of working trips under this policy and an average trip length of 6 km the reduction is 10 million passenger-km per day.

This is equivalent to a reduction of 0.36 -0.44 million tonnes of CO_2 per year under the typical modal composition for work trips.

5. **Modernizing the bus fleet, introducing low floor buses and introducing new bus routes/frequency in cities to attract private vehicle users to buses**

The bus fleet operated by Sri Lanka Transport Board and Private Bus Operators in Sri Lanka is around 5000 and 20,000 buses respectively. This value has remained stagnant for over a decade while the other modes have increased considerably. Therefore, the bus fleet must be expanded to provide new services for various market segments.

The addition of 5,000 more buses along existing bus routes and selected new routes would improve the travel time reliability and service quality to public transport users. These buses can target certain niche markets such as school services, office transport, nighttime services, rural areas and divert existing private vehicle users. In addition ticketing system, real time bus information systems, bus terminal facilities should be improved in parallel to provide an overall improved user experience.

An addition of 5,000 buses has the potential to reduce up to 8000 passenger km of travel by private modes per bus. This is equivalent to annual saving of 0.62 million kg of CO_2 per year.

The project could commence in the year 2025 and increase the bus fleet in stages by the year 2045. Around Rs. 250-300 billion would need to be spent over the 20-year period to expand the bus fleet and other facilities such as bus bays and facilities at terminals and maintenance cost. (Replacement programs are given with the strategic plan).

6. **Implement a price formula for petrol and diesel to reflect global petroleum prices and exchange rates**

Sri Lanka has not adjusted the fuel prices to reflect changes in the exchange rate and global energy prices for a considerable period. This has made fuel relatively cheaper compared to other commodities which has increased with inflation. It has been found that the long-term price elasticity of fuel is in the range of -0.4. Considering the long-term inflation rates and currency depreciation rates the fuel price may have increased by on average around 6-8% p.a, if so, the fuel demand could have reduced by around 3% compared to current demand. (Price formula must reflect which must be explored during the action plan detailing stage)

Therefore, in the long term, implementation of fuel pricing policy that reflects its actual cost is likely to reduce the fuel consumption by 3%. With a more aggressive pricing strategy that considers the environmental cost of fuel consumption is likely to reduce the demand by 5%.

This will result in a reduction of CO_2 by 1 million tonnes kg by the year 2050.

7. **Transport Demand Management Strategies in Key Cities**

The following measures could be implemented in major cities to discourage private vehicles entering the city area. However, the success of these is dependent on the availability of alternative modes of public transport with sufficient capacity and service quality.

- Parking management: prohibit roadside parking, increase parking fees
- Park and ride system at main corridors for vehicles entering the city
- Congestion charging for selected zones to discourage vehicles entering during peak hours

More than 700,000 trips were recorded to have entered Colombo City area from outside in the ComTrans Study (2014) survey and close to 30% are via private modes. Considering all the main cities in the country, around 500,000 passenger trips per day in private vehicle modes can be potential reduced from entering main cities.

This is equivalent to reducing 4 million veh-km per day and 0.4 million tonnes of CO_2 per year.

This would cost around Rs. 50 billion and projected to be implemented over a period beginning from 2040-2050. If ERP (congestion charging) system is to be implement, that cost has to be separately accounted for considering the implementing area and technology used.

8. Implementation of LRT network in Colombo

The Light Rail Transit Network was proposed as a key project to improve the public transport system in Colombo and the suburbs. Initially the Malabe corridor has been identified to implement the project with expansions to other areas in Colombo also being developed as part of the feasibility study.

Under the present economic context, it is envisaged that the implementation of the LRT is restricted to Malabe Corridor with extension to Kaduwela and further down to Kottawa to integrate with the KV line.

According to the feasibility study the expected emission reduction is around 0.1 million kg CO_2 per annum. However, the actual emission reduction will depend on the ridership level which is also linked to the land use development strategy along the LRT corridor, transport demand management measures, feeder services at the stations linking the trip generation zones in the area etc. It is not prudent to make assumptions in that regard in this study.

The project cost is around Rs. 550 billion and if constructed is more likely to take place after the year 2025 for a period up to 2030.

9. E-Mobility

Public Transport-Rail

Electrification of Urban Rail Tracks

In step number one, the electrification of five main lines within the urban geographical limits is considered, as shown below. This option was considered after looking at the cost of transformation and the frequency of the train that travels within these five lines, as shown in Table 4.14.

Table 4.12: Proposed Railway Electrification Program

Year of Electrification	Railway Line	Rail Distance (km)
2030	KV Line- Fort to Padukka	37.2
2035	Coastal line- Fort to Kaluthara	41.9
2040	Puttalam line- Fort to Ragama	15.6
2045	Northern line – Fort to Polgahawela	73.9
	Mainline -Fort to Polgahawela	

Once electrified, the following savings in terms of engine km (burning diesel fuel) can be expected.

Table 4.13: Train km saving and the electricity requirement for electrification of Railways

Rail Line	Track Length	Train km Saving per Annum	Electricity Requirement (kwh) per Annum
KV line- Padukka	37.18	205,234	1,231,402
Coastal line- Kaluthara	41.87	711,455	4,268,730
Puttalam line- Ragama	15.55	94,420	566,518
Main line –Polgahawela	73.882	1,787,353	10,724,120
Northern line - Polgahawela		572,733	3,436,400
Total	**168**	**3,371,195**	**20,227,169**

Since, on average, a diesel engine travels 2.5 km per litre, diesel savings of 8 million litres can be estimated. In turn, 22 million kg of CO_2 can be reduced per annum from this initiation. At the same time, the Table above shows the electricity required to run the electrified trains in the urban context, which is going to be a demand increase for the energy sector.

Decarbonisation of Long-Distance and Freight Rail

Beyond the urban limits, since the frequency of train travel is less, the electrification of such a long distance may not be prudent. Hence, it is proposed to use hydrogen-fuelled engines to run these trains beyond the urban limits to far distances which is a carbon-free solution provided hydrogen is from abundant renewable energy sources. This initiative is not so new since Germany has already started using hydrogen-driven engines in their trains, and the Indian railway is the next waiting operator expecting a major shift.

The advantage of shifting to hydrogen-driven engines in railways is that sometimes electrification may not be a good solution in remote areas, where breakdowns in the electricity grid are experienced over long periods, even today. On the other hand, this option is just a change in the engines, and there is no cost associated with changing the cabins or upgrading the other infrastructures. Furthermore, operators of trains at less frequency due to lower demand, would not be able to cover the high electrification cost. Thus, a shift to hydrogen-driven engines seems to be the most economical and practical solution for Sri Lanka.

So, in the years 2045 to 2050, we expect all our long-distance trains to be driven using hydrogen engines and assume that more efficient hydrogen engines will be available in such time, than what we have today.

This way, we can fully decarbonise the railway transport, saving about 71,000 tonnes of CO_2.

Public Transport-Buses

Inter-Provincial

In Sri Lanka, there are inter-provincial buses operated by SLTB and the private sector. All private sector buses are registered at National Transport Commission (NTC), and according to the NTC data, there are 3,100+ buses providing long-distance service on a daily basis. On an average day, cumulatively, 0.8 million km are travelled, consuming 0.25 million litres of diesel. Therefore, private buses would emit about 242,000 tonnes CO_2 per year and assuming a similar contribution is from SLTB, the total CO_2 contribution from the interprovincial bus transport could be estimated as 485,000 tonnes of CO_2. (using an emission factor of 2.7 kg per litre disel)

The most practical solution available for the decarbonisation of inter-provincial buses is to introduce electric buses in stages so that the capital cost burden to the government can be spread over the years.

Therefore, the following bus electrification plan is proposed, and subsequent savings on CO_2 as well as additional electricity requirement is also calculated and depicted in Table 4.16 below.

Table 4.14: Bus electrification Plan and Electricity requirement for implementation

Year	*% of Buses Electrified*	*Electric Bus Km per Annum*	*Electricity Requirement (kwh)*
2030	10% of the Interprovincial buses electrified	62,901,384	88,690,952
2035	20% of the Interprovincial buses electrified	125,802,769	177,381,904
2040	50% of the Interprovincial buses electrified	314,506,922	443,454,760
2045	75% of the Interprovincial buses electrified	471,760,383	665,182,140
2050	100% of the Interprovincial buses electrified 1	629,013,844	886,909,520

Note: Total buses considered here (Private+SLTB)

As shown in Table, 887 million units of additional electricity are required for provincial bus electrification, which would, in return, save 485 million kg of CO_2 emissions.

Provincial

Similarly, provincial bus transportation is also provided by the same two operators and assuming a 50:50 share, the following electrification strategy is proposed. Data from Western and Southern Passenger Transport Authorities were received, and calculations were carried out accordingly.

In Western Province, 5,913 private buses are registered, and on average, 4,173 buses are in operation on a daily basis covering 833,687 km. Assuming that SLTB also provides a similar service in the Western Province, it can be estimated that a total of 1.7 million km travelled, burning 476,392 litres of diesel and emitting 1.3 million kg of CO_2 (annually 469 million kg of CO_2).

In Southern Province, 1,239 buses are in operation on a daily basis running 16,993 km. Considering the same assumption as above, the total bus km operated in Southern Province can be estimated as 33,987 km burning 9,710 litres of diesel and emitting 26 million kg of CO_2 (annually 9.6 million kg of CO_2).

Looking at the vast disparity in the operating km in the two provinces, it is difficult to make and estimation for other provinces. However, such an estimation is needed since there is no data obtained so far from such passenger transport authorities. To be on the safe side, Southern province performance is considered for other remaining seven provinces as well.

Thus, the bus electrification plan shown in Fig 4.17 can be proposed to achieve carbon net zero by 2050.

Table 4.15 : Proposed Bus Electrification Plan

Year	% of Buses Electrified	Electric Bus Km per annum	Electricity Requirement (kwh) per year
2030	None	0	0
2037	10% of the Bus Fleet	70,783,063	99,804,119
2043	30% of the Bus Fleet	212,349,189	299,412,356
2047	60% of the Bus Fleet	424,698,378	598,824,713
2050	100% of the Bus Fleet	707,830,630	998,041,188

As shown above, this requires about 998 million units of additional electricity per annum by 2050, saving 546 million kg of CO_2.

Contribution from Private and Freight Vehicles

In the transport sector, the biggest fossil fuel consumption is by private vehicles (including freight vehicles) , burning a total of 3 million tonnes (petrol and diesel) and emitting 9 million tonnes kg of CO_2 annually based on 2020 data. Since vehicle imports are restricted to the country, the number of vehicles would not increase, and this situation can be expected for at least another few years. At the same time, due to the economic crisis and considering the price of a litre of fossil fuel, there will not be any noticeable change in the number of km travelled using private vehicles, and hence it can be prudently assumed that up until 2030, the current scenario will continue.

The only feasible option to decarbonise private vehicle emissions is to replace fossil fuel-based with electric vehicles. This is the vision of some car manufacturing companies as well. For example, Volkswagen will mainly be producing electric vehicles for the next couple of decades, and their plan is to reach net carbon zero by 2050. In similar concepts, if SL wants to be enjoying the same status, the imports must grant only fully electric vehicles so that eventually, our vehicle fleet will be electrified over the 20 years or so beyond 2030. Since freight vehicles are also within this private vehicle category, government subsidies may have to consider electrifying the freight fleet because the capital cost of the vehicle is too high. At the same time, electric charging points, electricity generation to meet additional demands, and the development of other necessary infrastructure are essential for electrification to be a reality.

Sample Calculation:

If we expect a 5,000 million kg reduction of CO_2 emissions by private electric vehicles, the amount of electricity increase can be calculated as follows.

The expected reduction of CO_2 (kg)	5,000,000,000
Number of gasoline litres burnt (assuming 2.3kg of CO_2/litre)	2,173,913,043
Approximate number of km from given litres of gasoline (8km/l)	17,391,304,347
Electricity required to run additional km (0.2 kwh/km)	3,478,260,869

As per the calculation, an additional 3,478 million units of electricity is required to save 5,000 million kg of CO_2.

Considering the past vehicle import rates, it can be assumed that the following numbers (Table 4-18) may apply from 2030 onwards and 5% increase to the base number is expected every year after 2030. It is important to note that all these new imports are electric vehicles and with this we are expecting to replace the existing fleets over a long period of time. In other words, existing fossil-fuelled vehicles will be used for some more time and eventually all fossil-fuelled vehicles will be replaced by electric vehicles in the long run.

Table 4.16: Expected Number of Electric Vehicles Imports by 2030

Cars	80,776
3W	20,063
MC	339,763
SUV Van	16,931
Lorry	7,055
Trailers	1,989
Ambulances	325
Tractors	7,460

Hence we can expect a 1,853 CO2 reduction (million kg) in year 2030 and 3,706 in year 2050.

Table 4.17 : Summary of CO_2 emission reduction by 2050 and additional electricity requirement for transport sector mitigation actions

Activity	CO_2 reduction by 2050 (million kg)	Additional Electricity Requirement (million kw/h)
Railway Electrification	22.8	20.2
Railway- Hydrogen Energy	48.3	0
Inter-Provincial Bus Electrification	485	887
Provincial Bus Electrification	262	438
Private Vehicle Electrification	3,706	4,441

Both maritime and aviation sectors were not specifically addressed in the study mainly due to limited feedback received from state agencies on specific strategies that have been proposed. Moreover, the scope of the study requires identifying relevant stakeholders and specifying implementation timeline and cost, along with the expected emission reduction due to the strategies. In the absence of the specific strategies, reliable estimates of this could not be made. Considering both aviation and maritime emission reduction targets are largely influenced by the goals set by organizations such as International Maritime Organizations and International Civil Aviation Organization and complied with by international shipping and airline companies, it is unclear how the government strategies could influence that to a significant extent. It is also unclear the future ownership status of state owned enterprises such as Sri Lankan Airlines, therefore proposing long term goals is not considered prudent.

4.5.3 Industry Sector

The actions proposed to achieve the NDCs in the Industry Sector are listed below.

1. Promote Resource Efficient Cleaner Production (RECP) practices by conducting energy audits, including low carbon technologies and processes, improving water use efficiency in selected industrial subsectors, and promoting energy-efficient appliances and technologies
2. Establish eco-industrial parks and villages by incorporating the maximum possible green industrial concepts and introducing policy and regulatory regime
3. Adopt the Circular Economy concept for selected industries by conducting a survey to

identify and determine the potential subsectors for the implementation, introducing the life cycle approach, practicing the industrial symbiosis concept, establishing a pilot project on the zero-waste concept, adopting ISO standards for the circular economy concept (ISO/TC 323) and building industry capacity to adopt the circular economy concept

4. Introduce tri-generation facilities in selected industries by carrying out rapid assessments in 10 industrial parks and a detailed assessment in one of the BOI industrial parks for piloting, developing business models and funding options, implementing one Tri-generation facility as a pilot project, and expanding it if it will be successful and making provisions in new developments through policy instruments
5. Encourage GHG reduction of clinker production in the cement industry by making necessary amendments to Sri Lanka Standard Institute (SLSI) standards for cement production
6. Generic enabling activities such as facilitating industries to adopt relevant ISO systems, introducing and promoting suitable tax incentives, facilitating the entry of ISO-certified companies to the Green Public Procurement system of Sri Lanka, facilitating transformational investment and favorable loans, introducing a national policy to address siting of industrial parks and stand-alone industries, ensuring the availability of sustainable biomass and promoting National Green Reporting System (NGRS)
7. In relation to all the itemized proposals above (1-6) enact legislative punitive measures, as found in advanced countries, where *polluters pay dearly* and therefore the inclination to violate the environment is treated with predictable legalized repercussions

According to the NDCs (MoE, 2021), implementation of these activities without hindrances is expected to reduce the GHG emissions by a total of 3,570,000 tonnes (7%) by 2030, out of which 2,088,000 tonnes (4%) will be unconditional and 1,482,000 tonnes (3%) will be conditional. In addition to these actions, other technical options mentioned in Third National Communication of Climate Change in Sri Lanka (MoE, 2022) will be considered and new actions will be developed to achieve net zero carbon emission in Sri Lanka. Qualitative and proportional emission reductions (as%)are shown in below diagrams (Figure 4.5 and 4.6).

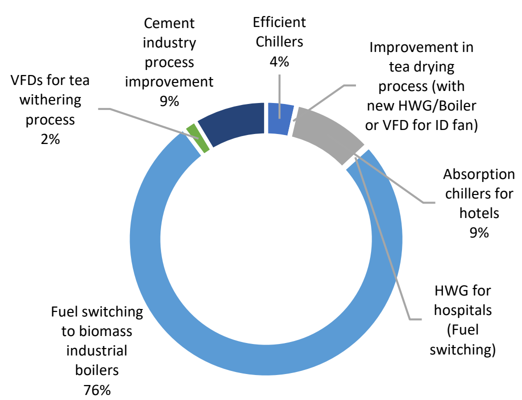


Figure 4.3 : NDCs unconditional and conditional

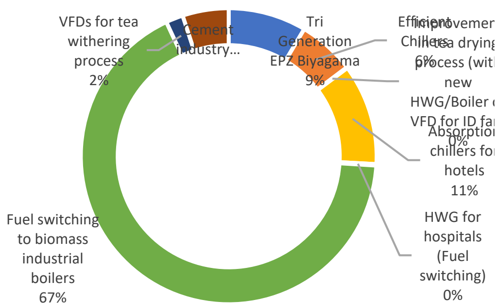


Figure 4.2 : NDCs based unconditional reductions

National Road Map milestones for achieving Carbon Net Zero

Few milestones proposed particularly relevant to Sri Lanka are highlighted as follows;

- Industry process efficiency improvement in reducing industry process (IP) related emissions especially focusing cement and lime industries,

Considering the prevailing national economic crisis situation, prioritizing climate net zero targets will be a challenge. But proper, country specific and specially science-based targets (SBTs) will offer definite national sustainability benefits beyond mere economic benefits. Therefore, in achieving national net zero emissions, it is highly recommended to give the appropriate priority to the strategic options and targets developed on SBTs which are providing simultaneous economic and sustainability (both in short term and long term) benefits.

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.

4.5.4 <u>Waste Sector</u>

Waste management is a critical aspect of modern societies as it impacts not only the environment but also human health, social well-being, and economic prosperity. The fast-growing urbanization and globalization trends have led to an exponential increase in waste generation and improper waste management practices, resulting in significant environmental and health impacts. In particular, the waste sector contributes to greenhouse gas (GHG) emissions, which drive climate change. Therefore, reducing waste related GHG emissions has become an urgent priority for both developed and developing countries.

To mitigate the impacts of waste related GHG emissions, various mitigatory actions have been taken at the national and global levels. One of the critical actions is the reduction of waste amount at the source, which is achieved by introducing MSW segregation categories, improving waste collection and transportation, and creating awareness among the public and industrialists. Policy on polluter pay principles to be introduced island wide by the local authorities. Additionally, deposit and refund systems for plastic bottles, glass bottles, aluminium cans, and other waste items have been established to motivate people to reduce waste generation.

Further adoption of the 3R practice (Reduce, Reuse, Recycle) is necessary to reduce waste generation and improve resource efficiency. The circular economy concept has been introduced to promote the redesign, reuse, and rethink of products and materials, which helps in reducing the waste and GHG emissions. To enhance the circular economy, various initiatives have been launched, including subsidies for community-based composting, supporting the production of hybrid fertilizers, and redirecting MSW away from landfills for agricultural use.

GHG emission reduction is enhanced using electric vehicles in waste transportation and waste to energy plants. Establishing sanitary landfills and daily covers for open dumps is another critical action that has been taken to reduce waste related GHG emissions. Additionally, various strategies have been introduced to build a zero-carbon economy, including the introduction of zero-carbon building materials and the offering of national research grants for zero-carbon innovations.

Waste management and GHG emissions reduction are interdependent and require a comprehensive approach that involves the collaboration of various stakeholders, including the government, private sector, civil society, and international organizations. The mitigatory actions mentioned above are critical steps towards achieving a sustainable waste management system and reducing waste related GHG emissions. By implementing these measures, we can create a cleaner, healthier, and more sustainable future for all. According to the National Action Plan on Plastic Waste Management goal 11 there will be non-recyclable remaining at the end stage of the life which accounts for the high caloric input necessary for the plant. The strategic location for the WtE should be identified such that the high amount of waste reaches the plant with minimal transportation. The appropriate land extent must be taken into the account while commissioning the plants. The following strategies are proposed for the waste sector to achieve net zero carbon emission in 2050,

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

The actions proposed in following strategies are given under table- 4.20 and 4.21

The details of the mitigatory actions are shown in table 4.20

Table 4.18 : Mitigatory Actions for the Waste Sector

No	Mitigatory Actions
1.0	**Using biochar for daily cover in landfills and open dumps**
1.1	Pyrolyzing conversion of municipal solid waste into biochar which supports the circular economy
1.2	Introducing biochar as a renewable energy resource such as carbon fuel cells, porous catalysts, bio-oil, biochar coal, syngas, etc.
1.3	Using biochar for carbon sequestration
2.0	**MSW growth reduction**
2.1	Municipal solid waste & wastewater growth reduction
2.2	Introducing municipal solid waste segregation categories, improving waste collection and transportation problems

No	Mitigatory Actions
2.3	Improving laws, rules, and regulations and formulating economic measures to create motivation for waste reduction
2.4	Establishing polluter pay principles for waste reduction
2.5	Encouraging entrepreneurs to reduce disposable waste container sales and promoting safe reuse containers
2.6	Promoting food waste separation at source, obviously after avoiding the waste as much as possible
3.0	**3R practice & promote recycling and use of recycled materials**
3.1	Mandate 3R practices
3.2	Create awareness among industrialists that improve materials and materials flows like reuse and recycling
3.3	Transform waste into reverse-engineered products
3.4	Mandate recycled content requirements and waste reduction measures
4.0	**Methane recovery for SynGas production from open dumps and sanitary landfills**
5.0	**Constructed wetland for wastewater treatment and reuse treated wastewater for greening**
5.1	Vertical Sub Surface Flow Constructed Wetland (VSSFCW)
6.0	**Transforming the waste collection garbage trucks into electric trucks**
7.0	**Introducing waste to energy plants for other provinces**
8.0	**Establishing sanitary landfills for residual wastes**

Biogas community level from fecal material

Community level Biogas production from faecal material at the community level is a highly effective way to reduce greenhouse gas emissions. When untreated human and animal waste decompose, they release methane, a potent greenhouse gas that contributes significantly to climate change. However, by using anaerobic digestion to convert the waste into biogas, the methane emissions are captured and turned into a renewable energy source. Biogas production not only reduces methane emissions, but it also displaces the use of fossil fuels for cooking, heating, and lighting, further reducing greenhouse gas emissions. This innovative solution not only provides a source of clean energy but also addresses sanitation and hygiene issues, especially in rural areas where access to proper sanitation facilities is limited. Overall, biogas production from faecal material at the community level has the potential to significantly reduce greenhouse gas emissions while promoting sustainable development.

Table 4.19 : Mitigatory Actions for the Waste Sector

No	Mitigatory Actions (unquantifiable/to be quantified in future)
1.0	**Refunds & incentives for proper waste management**
1.1	Supporting deposit & refund systems for plastic bottles, glass bottles, aluminum cans
2.0	**Promote circular economy in supply chains and construction industry**
2.1	Redesign, reuse & rethink for circular economy
2.2	Boosting the energy and resource efficiency of products
2.3	Enhancing the number of recycled materials in products while maintaining their functionality and safety; facilitating remanufacturing and superior recycling
2.4	Limiting single-use and combating premature aging
2.5	Putting a stop to the destruction of durable items that have not sold
2.6	Encouraging business models that allow producers to retain ownership of the product or accountability for its performance over its entire lifecycle
2.7	Rewarding products depending on their various sustainability performance
2.8	Design for deconstruction in such a way that the materials used for construction can be reused in new construction with minimum alterations
3.0	**Efficient waste management**
3.1	Supporting provincial administrative organization to make waste management systems, reuse systems and data management systems
3.2	Restrict outdoor burning and improve the operation of clean development mechanisms
3.3	Addressing the presence of dangerous chemicals in waste
3.4	Addressing the prevalence of microplastics in the environment
3.5	Establishing and standardizing measurement techniques for accidentally released microplastics, particularly from tires and textiles
3.6	Phytoremediation for E-waste contaminated sites
4.0	**Biogas from fecal sludge at community level**
5.0	**Hybrid fertilizer production and Subsidy free community-based composting**
5.1	Redirect MSW away from landfills so that it can be used as a supplement to fertilizer on agricultural fields so, aiding in preserving soil fertility and recycling trash
5.2	Combine agricultural compost with municipal solid waste compost
6.0	**Introducing the waste management activities and the emissions reduction opportunities**
6.1	3R practice as well as saving money, energy, and natural resources related to life cycle management

No	Mitigatory Actions (unquantifiable/to be quantified in future)
6.2	Introduce strategies on the national level to build an economy that keeps materials, products, and services in circulation for as long as possible
7.0	**Promoting zero-carbon innovations**
7.1	Offering National Research Grants for zero carbon innovations
7.2	Introducing zero-carbon building materials
7.3	Introduction of carbon adsorbing materials
8.0	**Community participation, empowerment, and capacity building**

4.5.5 Agriculture Sector

Feasible Strategies

Following strategies are proposed to be adopted in the agriculture sector to reduce GHG emissions:

1. Reduce methane emission from paddy fields by removing rice straws and through good management practices.
2. Use alternatives to Chemical fertilizer for reducing N_2O emission.
3. Reduce methane emission from livestock by improving feed quality and animal comfort.
4. Reduce N_2O emission in soils due to microbial activities.

Following strategies can be adopted to increase carbon sequestration in the agriculture sector:

1. Adopt 'evergreen agro-ecosystem concept' to improve carbon sequestration from paddy fields and rainfed uplands.

Following strategies are also possible to be included in future planning, when information is available to do so:

1. Improve land management practices in agricultural lands to enhance the carbon stock in the soil.
2. Improve crop management practices in tea plantations.

Mitigation Actions proposed to be implemented under the Strategies

Strategy 1. Reduce methane emission from paddy fields by removing rice straws and through good management practices

a. Removal of paddy straw from the paddy field for manufacturing paper, boards and packaging materials and producing biofuel blocks.
b. Reduce post-harvest losses during harvesting and transport to minimize GHG emission from transport and agricultural product residues

c. Establish subsistence and/or polyculture farming to maintain healthier soils
d. Promote diverse cropping systems and a need-based economy
e. Addition of rice straw-derived biochar to lower methane emissions in increased temperature and carbon dioxide conditions, congruent with future climates.
f. Responsible water management such as slower infiltration techniques, breaking up of soil aggregates or alternate wetting and drying (AWD)
g. Policy initiatives to encourage sustainable farming practices and address current subsidies. (Durbin, 2017)
h. Promote rice production in upland areas, in which the fields are not maintained in flooded conditions, generates substantially less methane per hectare and per unit of rice.
i. Adaptation of good management practices for soil and water management particularly large in areas where two or three crops of rice are produced each year. (Wichelns, 2016).
j. or three crops of rice are produced each year. (Wichelns, 2016).

Strategy 2. Use alternatives to Chemical fertilizer for reducing N_2O emission:

a. Integration with organic fertilizers (Organic Farming)
b. Promote slow/controlled N-releasing fertilizers and increase their effectiveness.
c. Deep placement and reduction of frequency of application of N fertilizer,
d. Use of N transformation inhibitors to scale back the hydrolysis of urea to ammonium by soil urease enzyme.
e. The use of nitrification inhibitors to scale back the accumulation of nitrate also will help to reduce GHG emissions.
f. Adjust fertilizer rates to coincide with plant needs.
g. Place fertilizer near plant roots (but not too deep in the soil);
h. Apply fertilizer several times each year, rather than only once.
i. Adopt IPNS (Integrated Plant Nutrition System) approach
j. Adopt Climate Smart Agriculture (World Bank & CIAT, 2015)

Strategy 3. Reduce methane emission from livestock by improving feed quality and animal comfort.

a. Supplement with fodder trees, rice straw, and low-cost concentrate. – Here, lower CH_4 observed with legumes is attributed to lower fiber content and faster rate of passage of feed through the rumen; thus, intakes are higher with legume forages.
b. Use of total mixed ratio – improves productivity and reduces methane emissions.
c. Supplement forage diet with Gliricidia blocks- Promotes high dry matter intake and has a faster rate of passage through the rumen and reduction of CH_4
d. Animal comfort (heat stress management)- Enhanced animal productivity and reduced GHG emission intensity.
e. Use methane for their thermal energy use as well as for power generation especially in larges farms

Strategy 4. Reduce N_2O emission in soils due to microbial activities

a. Manure management from livestock
b. Crop residue management in agricultural fields
c. Management of organic soils to minimize N_2O emission

Strategy 5. Adopt 'evergreen agro-ecosystem concept' to improve carbon sequestration from paddy fields and rain-fed uplands

Main features of the ever-green agro-ecosystems concept can be listed as follows:

- Cultivation of crops with different duration to keep green cover even during the harvesting stage of one crop;
- Cultivation of crops leaving zero fallow period of the land;
- Farming models, which combine seasonal, semi-perennial and perennial crops ensuring the green cover around the year;
- Green manure plants such as gliricidia, adathoda, erithrina, thespesia etc. are grown as hedges with strict frequency of pruning;
- Shade management is adopted to minimize light competition and to maintain the crop land with evergreen situation;
- Live fence is maintained with plants to create a stratification enabling to act as wind barrier as well as favourable micro-climate in the crop field; and
- The farmer should have a field management / self-evaluation schedule for his convenience to ensure the sustainability of the agro-ecosystem

Strategy 6. Improve land management practices in agricultural lands to enhance the carbon stock in the soil

a. Minimize tillage operations.
b. Restore degraded land, improving pasture management.
c. Reduce fallow periods.
d. Add animal manures to the soil.
e. Crop residue management.
f. Use legumes and/or grasses in crop rotations.
g. Convert marginal cropland to perennial grass or agroforestry systems.
h. Use rotational grazing and high-intensity/short-duration grazing.
i. Plant shrubs and trees as shelterbelts.
j. Restore wetlands.

Strategy 7. Improve crop management practices in tea plantations.

a. Introduce shade trees which are having higher carbon sequestration compared to tea bushes
b. Select shade tree species according to the region[2]
c. Adopt proper sustainable land management practices

---

[2] T. L. Wijeratne, W. A. J. M. De Costa and M. A. Wijeratne, 2014. Carbon Sequestration Potential of Tea Plantations in Sri Lanka as an Option for Mitigating Climate Change; a Step towards a Greener Economy, Conference Paper – Fifth Symposium on Plantation Crop Research

d. Strengthen tea small holding development societies
e. Establish biological hedges (wind barriers and use of tea plant itself without pruning)
f. Establish grass hedges (*Vetiveria zizanioides*, *Cymbopogon winterianus* etc.)
g. Establish cover crops (Ex. Mal Ratakaju (*Arachis pintoi*)

4.5.6 <u>Forestry Sector</u>

According to the updated NDC (2021-2030), 18,000 ha 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 Net Zero Road Map and Strategic Plan, the Forest Department is hoping to reforest/afforest 200,000 ha of land by 2050. This land is included in the land under the category 'Other State Forests' which was vested under the management of Forest Department in the 5/2001 Circular but was cancelled subsequently and these were vested under the custody of Divisional Administrations. However, out of the 500,000 ha, 200,000 ha had been released to the Forest Department for restoration/ reforestation/ afforestation. It is also hoped to increase the contribution of trees outside forests to the GHG mitigation scenario. These include homegardens, coconut plantations, shade trees in the tea plantations, urban trees and avenue trees, 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. Tables 5 and 6 in Annexure 3 show the net carbon sequestration of forests, trees outside forests and mangroves in Baseline Scenario and Net Zero Scenarios respectively.

4.6 Overall effects considering the cross-sector impacts

The following list is a summary of the feasible strategies and mitigation actions for achieving targets for the six sectors as described in sections 4.5.1 to 4.5.6:

a) Energy Sector

- Decommissioning coal and diesel power plants
- Addition of natural gas power plants
- Addition of renewable energy such as pumped storage, mini hydro, biomass, wind and solar with integration of energy storage devices such as battery storages and pump hydro plants.
- Nuclear-based electricity generation
- Decommissioning of natural gas power plants
- Adding Cross Border Interconnection of India and Sri Lanka.
- Energy efficiency, Conservation and Demand Side Management (DSM)
- Introduction of green hydrogen
- Introduction of Carbon capture and storage (CCS)
- Dedicated energy plantations for Biomass

a) Transport Sector

- Improving the pedestrian infrastructure on collector type roads in the country
- Promoting cycling
- Promoting remote working
- Promoting e-commerce and e-learning
- Attracting private vehicle users to buses
- Implementing a price formula for petrol and diesel to reflect global petroleum prices and exchange rates
- Prohibition of roadside parking, increase parking fees in cities
- Park and ride systems at main corridors for vehicles entering the city
- Congestion charging for selected zones to discourage vehicles entering during peak hours
- Implementation of LRT network in Colombo
- Electrification of urban rail tracks
- Decarbonisation of long-distance and freight rail with hydrogen fuelled engines
- Introducing electric inter-provincial and provincial buses
- Replacing fossil fuel based private vehicles with electric vehicles
- Introducing electric charging points and necessary infrastructure

b) Industry Sector

- Promoting Resource Efficient Cleaner Production (RECP) practices
- Establishing eco-industrial parks and villages
- Adopting the Circular Economy concept
- Introducing tri-generation facilities
- Substituting clinker with other materials in cement production (Amendment Sri Lanka Standard Institute (SLSI) standards for cement production enabling the increase of ash and other similar materials as substitutes for clinker)
- Implementing polluter pays principle

c) Waste Sector

- Reduction of the waste amount at the source
- Promote recycling and use of recycled materials
- Promote Circular Economy in Supply Chains
- Efficient waste management

- Biochar used as carbon sequestration
- Hybrid fertilizer Production
- Identifying the waste management activities and the emissions reduction opportunities that can be implemented in Sri Lanka
- Promoting zero-carbon innovations

d) Agricultural Sector

- Formulate policies to establish hydrology unit or section or laboratory at all the major plantation research institutes (Tea, Rubber, Coconut etc.) to regain the lost groundwater balance from the central hills.
- Effective Land management practices
- Alter the diets of livestock to reduce methane emissions
- Choosing management practices that enhance productivity
- Manure management practices to reduce methane emission
- Biogas production using manure

e) Forestry Sector

- Establish new forests (afforestation)
- Protection of existing natural forests and forest plantations
- Restoration and reforestation
- Increase the contribution of trees outside forests
- Increase blue carbon ecosystems such as mangroves, seagrass beds and salt marshes

The above six sectors are considered separately for the estimation of current emissions, targets for emission reduction and increased sequestration/absorption, feasible actions for achieving targets, and prediction of emissions. However, there are many linkages among the sectors, which causes impacts on each other when strategies and actions for mitigation are proposed for one sector. Some such linkages that present an additional burden of carbon emissions that need to be mitigated as well as positive impacts on the control measures are shown in Figure 4.7. For example, implementation of LRT network in Colombo, electrification of urban rail tracks, introducing electric inter-provincial and provincial buses, replacing fossil fuel based private vehicles with electric vehicles and introducing electric charging points and necessary infrastructure, all of which are aimed at shifting the transport sector from the use of fossil fuel to electricity, transfers a heavy demand to the energy sector, the emissions of which has to be dealt with by the energy sector. At the same time, activities such as promoting cycling, promoting remote working, promoting e-commerce and e-learning, attracting private vehicle users to buses and implementing a price formula for petrol and diesel to reflect global petroleum prices and exchange rates would reduce the demand for transportation, which would have positive impact on the demand side management for the energy sector.

In addition, some mitigation actions in one sector such as an increase of land used for 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. The actions used in the development of Figure 4.8 are those used in actions and strategies for Carbon Net Zero scenarios, to show the complexity of the interrelationships within the sectors.

In order to correctly reflect the carbon emission values when considering the overall effects, the sector consultants worked together to share the data and predictions. For example, the reduction in emissions due to actions like electrification in the transportation sector, where the energy source would change from petroleum use to electricity, resulted in the transfer of the emission load from the transport sector to the energy sector, due to the increase in electrical energy demand. Thus, the development of the road map was done interactively among the sectors, to achieve Carbon Net Zero in a holistic manner, rather than working in silos.

Social and gender issues that may arise from the proposed actions need to be effectively mitigated, and actions for assuring gender equity will be incorporated into the Road map. An economic analysis was carried out to find the best pathways for the country’s social and economic development, taking this as an opportunity for sustainable development, to rise from the present economic crisis faced by the country.

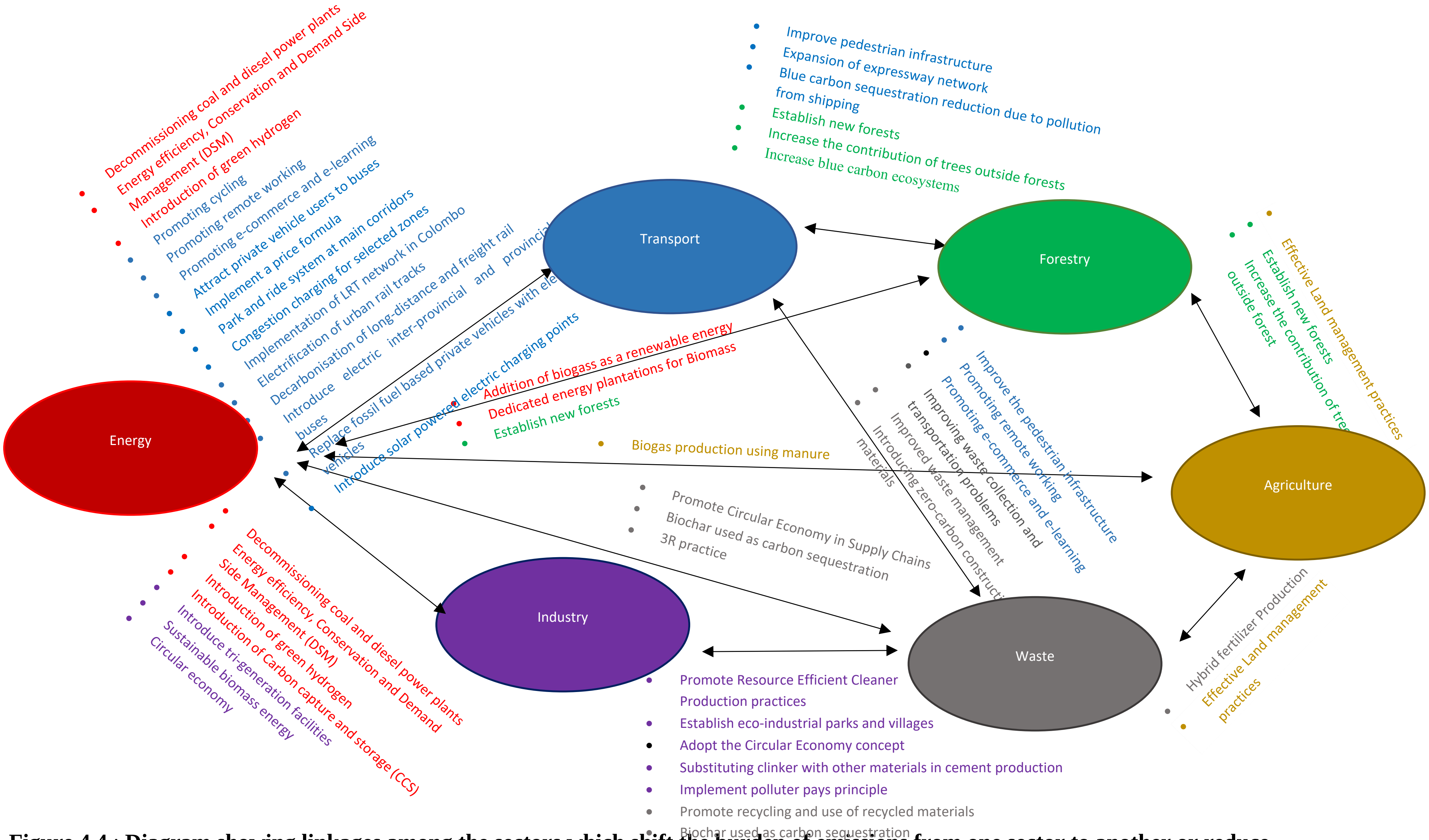


Figure 4.4 : **Diagram showing linkages among the sectors which shift the burden of emissions from one sector to another or reduce emissions from other sectors due to the proposed mitigation actions of one sector.**

4.7 Gender and social inclusion Analysis on actions proposed

Background

A common question raised by many of international endeavors drawn through many national and international treaties, conventions, acts and regulations to counter the negative ecological impacts of development and resulting social repercussions is whether the world can maintain total harmony between the ecological conservation and social and psychological wellbeing of the world population. When the factors that generate socio-economic differences among people are concerned, any particular measure of development does not seem to cater to equity and equality between people who have been divided on the basis of ownership and access to numerous facilities, resources, opportunities etc. placing them in a plethora of social hierarchies. Throughout the last several decades researchers have been searching for fair grounds which can be used as a premise for devising strategies to overcome these social issues pertaining to the maintenance of the balance between environmental conservation and social wellbeing.

"Paris Agreement on Climate change" as one of the key conventions which presents a highly ambitious plan to the world to reach Carbon Net Zero by 2050, addressing the grave issue of global warming, takes the magnitude of the social factors as of high importance in tackling the issue. It envisages that the parties involved in addressing climate change should "*respect, promote and consider their respective obligations on human rights, the right to health, the rights of indigenous peoples, local communities, migrants, children, persons with disabilities and people in vulnerable situations and the right to development, as well as gender equality, empowerment of women and intergenerational equity*" (UNFCCC 2016: 2). (See Annexure 2)

With the eye-opening questions raised in the pioneering text "Women's Role in Economic Development" by Ester Boserup (1970), attention was drawn to the issue of marginalization / exclusion of women in the development process, both as contributors and beneficiaries, catering to the adoption of many international conventions, acts and regulations. Apart from her major concerns on education and employment of women, Boserup (1970) also raised the concern on women's involvement with the environment. In 1988, Vandana Shiva raised a major concern on women's inseparable bond with the environment and the impact of the environmental destruction on the survival of women in her "Staying Alive" (1988) followed by the classic text "Ecofeminism" by Shiva and Maria Mies in 1993 drawing attention to the women's role in the conservation of the environment. Vandana Shiva (1988) critiques modern science and technology as a western, patriarchal and colonial project, which is essentially violent and propagates the same violence against women and nature. Despite many critiques and alternative suggestions, the above texts led the global community to seriously consider the gender aspects of environmental destruction and conservation as well as the global trajectory for development adopted so far.

Ensuring gender equality in all development programmes aiming at sustainability became a major concern since the Beijing Declaration and Platform for Action in 1995. The Paris Convention for Climate Change also deems gender equality as of utmost importance in this whole process towards carbon net zero 2050 planning and implementation including maintaining gender balance in all bodies and delegations constituted under the convention, responding to the differential needs, experiences, priorities and capacities of women and men at all regional, national and local levels.

Population Dynamics and Possible Impact on Carbon Emission

The last population census was carried out in Sri Lanka in 2011, and the final census report was published in 2012. According to this report, the population growth rate in the country in 2011 was 0.7% (Department of Census and Statistics, 2012). From the total population in 2011, 48.4% was male and 51.6% was female, and the sex ratio was 93.8%. The Department of Census and Statistics (2021) has calculated the crude birth rate per 1000 population in 2021 as 12.9, of which 13.5 are male and 12.2 are female. The estimated crude birth rate per 1,000 population in 2025 is 13, while in 2050 it is 10.5 (United Nations, DESA, 2022) showing a declining trend in population. Life expectancy at birth for men in 2025 is estimated to be nearly 73.6 years, while for women, it is 81 years. This shows that the male / female population in Sri Lanka is going to continue almost the same trends in the future. Literature has made evident that female population in general has exhibited a tendency to be more protective towards the environment (Ghaeli, 2019, Castañeda et.al. 2020, Nuber, 2021), so that it is possible to envisage that the potential gender scenario with the declining trend in population and the higher female ratio could have a profound impact in lowering of carbon emissions (see Annexure 1). However, such impact would be meaningful only if the country could reach substantial levels of gender equality allowing female population equal opportunities in entering societal echelons where they would be adequately empowered towards independent decision making.

Policies and Policy Gaps

There are a considerable number of policies and legislations introduced in Sri Lanka by various ministries and departments which have a stake with the subject matter related to the environment. The prime objective of these policies and legislations is conserving the environment and addressing climate change outcomes. However, most of these policies take a deep ecological perspective although some of them occasionally mention their relationship with social factors including gender as having some significance in addressing environmental issues. Nevertheless, those policy-based actions do not seem to pay an adequate concern on gender and social aspects as crucial in their remedial measures.

Review of what could be considered as most relevant policies and legislations in curbing the serious social and gender related repercussions on environment reveal that gender and social aspects of environment including carbon emission either has not been a concern or it only has been given marginal attention. The Ministry of Women and Child Affairs in a Cabinet Memo issued on 15th November 2016 under the title "Establishment of Gender Mainstreaming Programme at Ministerial Level" mentions that "…approval for 53 posts of Gender Focal Points has been obtained when graduate trainees were recruited in 2013" attached to all ministries, on the requirement made by the Commission on the Status of Women (CSW) at its

57th session held in March 2013 in order to curb all forms of violence against women and girls. The memo further says, “The expected targets of our ministry could not be achieved due to lack of support for those officers from the respective ministries they were attached to, lack of proper recognition for this subject and due to lack of proper guidance for those officers to act in relation to gender mainstreaming. At present only six (6) out of those officers remain”.

The establishment of the above-mentioned gender focal points seems to have become a failure despite the grave concern of the country on sexual and gender-based harassment and all forms of violence against women and girls. According to UNFCCC (n.d.), the gender and climate change decision 3/CP.25, paragraph 11, it "Encourages Parties to appoint and provide support for a national gender and climate change focal point for climate negotiations, implementation and monitoring". The UNFCCC secretariat has provided the list of nominated Gender Focal Points under the UNFCCC. Even though Sri Lanka is listed under the National focal points, the country so far has not followed the procedure to nominate a national gender focal point for climate negotiations (UNFCCC, n.d.). The requirement made by UNFCCC to establish gender focal points in relation to climate change under Climate Change Gender Action Plans (ccGAP) has never got implemented in policy planning in Sri Lanka, neither by Ministry of Women and Child Affairs nor by Ministry of Environment. The same lethargy in dealing with gender issues related to aspects of life of people and the country’s development is clearly visible in both these occasions despite the gravity of gender concerns all of the above domains seem to have.

In national policies and strategies related to environment, they have considered traditional knowledge in environmental conservation and preserving biodiversity as an important subject area, and propose strategies for preserving and incorporating traditional knowledge in environmental action. National Environmental Action Plan 2022 – 2030 has taken gender as a priority in planning for climate action. To achieve this goal, NEAP proposes to increase women’s participation in combatting climate change and to incorporate gender aspect “to all the new policies and plans related to climate change” (Ministry of Environment, 2022: 104 – 105) and also specifies the SDG targets (see Annexure 4) and NDCs (see Annexure 3) relevant to this process. NEAP also mentions gender mainstreaming as a noteworthy aspect especially in their agroforestry and woodlot establishment programme. National Environmental Policy and Strategies of 2003, as the first of their priority objectives, mentions the need for balancing social and economic development and environmental integrity to the highest capacity possible (Ministry of Environment and Natural Resources, 2003: 4). National Policy on Sustainable Consumption and Production for Sri Lanka also sees gender, inequality and inclusivity as cross cutting components in addressing SDG 12 (see Annexure 4). Even though the gender and social aspects of environmental action has been made one of the country’s earliest priorities as mentioned in 2003 National Environmental Policy and also in several other policy documents, prevailing national policies do not seem to have given adequate concern to the vitality of social and gender aspects in the process of environmental conservation in general or climate change in particular. This can be seen as a serious gap that need to be considered in 2050 carbon net zero strategies and action plans.

Analysis of the Gender and Social Impact of Proposed Mitigation Actions

Gender and social concerns of the proposed mitigation actions were identified on the basis of the literature review (see Annexures 4) and the analysis in relation to the views expressed by the respondents during the informal interviews (see Annexure 4). Views of the public on their knowledge and everyday experiences with regard to carbon emission becomes highly relevant in understanding the pertinence of these measures in the current socio-economic context of the country.

A stratified sample of 40 individuals purposively selected on the basis of urban/rural difference, gender and social class covering different locations in the country were informally interviewed in order to get their views along aspects related to carbon emission. Main themes included the knowledge and understanding of people on carbon emission, their everyday practices and relevance of those to carbon emissions, the difficulties experienced due to carbon emission as well as the problems they encounter when changing their lifestyles and domestic and livelihood practices despite their contribution to carbon emission. They were also consulted on their indigenous views and suggestions in mitigating atmospheric carbon dioxide increases.

Sample Distribution

Sector/ Social Class	**Gender**	
	Male	**Female**
Rural Upper/ Middle	05	05
Rural Low Income	05	05
Urban Upper/ Middle	05	05
Urban Low Income	05	05
Total	40	

The data collected from each respondent clearly demonstrate the need for obtaining public views in planning for low carbon emission measures for the country. Diversity in people's lives calls for a perspective that balance the social needs of people and the needs of a healthy environment in reaching carbon net zero 2050 goal. The data also pointed to the fact that knowledge and awareness on climate change and other environmental factors were significantly low among the population. The social and cultural practices towards the protection of environment supported in people taking certain protective measure in their daily life, however, apart from a segment of educated population, many were engaged in both environmentally positive and negative activities due to their ignorance.

Lack of alternatives for waste disposal seem to compel women to adopt environmentally destructive practices such as burning polythene even though they were somewhat aware of the harmful effects of this practice. Women seem to engage more in energy saving measures at home as a cost cutting measure since they are often responsible in balancing the household budget. Women commonly did not welcome the practice of work from home, both for themselves and for their husbands, due to family and household issues that cropped up when in such situations. Working from home also seem to cause stress for women and contribute to increased sexual harassment and domestic violence.

Women, more than men, seem to have been engaged in environmental activism and demonstrated a higher concern over the matters related to environment as it directly affects their responsibilities as women. However, women did not seem to have any decision-making power with regard to the matters related to environment, mainly due to low public engagement of women. Their individual contribution in environmentally protective practices at the household level was visible, nevertheless, they did not seem to engage in social and community actions related to the matter mainly due to lack of awareness and patriarchal social relations. Raising awareness among women and elevating them to decision making levels could immensely contribute to the lowering of carbon emission as well as in other environmental conservation activities.

The views of the respondents revealed that the country often experiences situations where expert solutions to problems get ignored or totally rejected by the public due to incompatibilities between these two sectors, experts and lay public. This could be a consequence of the absence of serious enough measures to familiarize the public with the necessary knowledge and/or awareness regarding the gravity of the issue or the potencies of the solutions given, or not considering the ground realities of the society by the experts in drafting solutions to problems they are dealing with. The following section attempts to see the gaps between these two sectors and to identify the need to come to mutually agreeable solutions by the experts in relation to the relevant proposed actions in each sector, as given in Table 4.22.

Feasible Actions for Achieving Targets and their Gender and Social Impacts

It is vital to note that, even though all the proposed actions under each sector are highly necessary to achieve carbon net zero goals, if in any case they have a tendency in unfairly treating any social group, the proposed actions will have a negative impact on sustainable development despite their potential to reach the primary target of attaining carbon net zero. Additionally, any planning that takes gender into account strives towards gender equity and equality in all spheres. Therefore, if a recommended strategy negatively affects a particular gender or social group, it cannot be considered effective from a gender and social standpoint. Gender equality includes engaging women and all gender groups in gender-sensitive planning, which goes beyond merely appointing more women to governing bodies. In that case, although increasing the number of female executives might advance both sustainable development and gender equality, what is more important is that they possess a high level of sensitivity with regard to both gender and social requirements of the society when dealing with sustainable development goals.

Also, even during an economic crisis, it cannot be said with certainty that the use of firewood constituted a permanent change in relation to cooking fuel, with the exception of a small percentage of people. Several gas vendors and companies in Sri Lanka have asserted that they were unable to handle the spike in demand during the crisis, despite the fact that this fact was not statistically supported in the sociological and gender research. Vendors claim that the demand for gas cylinders has surged over the past several months as a result of customers buying extra cylinders and a large number of middle-class consumers purchasing electric cookers (induction, infrared, etc.). Therefore, when considering the situation from the standpoint of the lay community, including the middle-income population, such a plan may not be very effective.

The gender and social impacts, as well as the proposed actions listed below, in Table 4-22, are therefore, intended to address these issues.

Table 4.20: Feasible Actions for Achieving Targets and their Gender and Social Impacts

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
Energy	• Addition of renewable energy such as pumped storage, mini hydro, biomass, wind and solar with integration of energy storage devices such as battery storages and pump hydro plants. • Dedicated energy plantations for Biomass	Before implementing pumped storage as a solution, planners may need to consider its social and gender costs such as the possible shortage of water for the agricultural activities and daily consumption of people living downstream. Water shortage world over contributes to increased vulnerabilities of population, specially women who are socially and culturally considered as primarily responsible for domestic provision of water. The high cost of installing rooftop solar power systems prevent its use at the household level. Introducing an economically feasible solar power system for small-scale industrial and business ventures and households.
	• Energy efficiency, Conservation and	Introducing energy saving equipment, the affordability of the vulnerable population needs to be taken into consideration.

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
	Demand Side Management (DSM)	Make low-cost appliances available. If housing is included in the term “buildings”, low-income groups (also pensioners, disabled, groups without old age financial support) and the 23.4% female headed households in the country have to be taken care of. Concessional provision of material and Cost effective equipment and special provision for small scale industries and female headed cottage industries
	• Introduction of green hydrogen • Introduction of Carbon capture and storage (CCS)	Here, R& D activities need to consider gender and socio-economic vulnerabilities as priority areas
	• Decommisioning coal and diesel power plants • Addition of natural gas power plants • Decommisioning of natural gas power plants after required time	Social impacts due to the loss of employment to the workforce when decommissioning of power plants needs to be mitigated.
	• Nuclear-based electricity generation	The risks associated with possible radioactivity releases have been a major social concern over the years, mainly due to lethality that supposed to be involved in regular or accidental situations and nuclear waste disposal. Therefore, considerable public protest against the use of nuclear energy could be expected. However, scientific investigations into the issue evidence that much of the risk perceptions of citizens are due to misperception and resulting anxiety (Huhtala & Remes, 2017).

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
		Although, the disastrous social impact of nuclear accidents could be very similar to the post-traumatic experiences of the affected population, the fear of chronic anxiety related to the impact of radiation cause individuals, families and communities to much greater worries and low resilience after the disaster. Possible impact of actual radiation and "radiation stigma" that could be both public and self-stigma is very specific to nuclear disasters (Maeda and Oe, 2017). The socioeconomic impact of nuclear disasters could vary according to the economic capacity of the country, worker population and population of the particular geographical area, the organizational strength, disaster preparedness, and the awareness of the public. These varying impacts were particularly visible in well-known nuclear disasters in Chernobyl, Soviet Union and Fukushima, Japan and also related to chemical disaster in Bhopal, India (Maeda and Oe, 2017; Shrivastava, 1987; Chernobyl Forum 2003-2005, 2005). Therefore, large-scale awareness campaigns imparting scientific knowledge to the public and strong precautionary programs to ensure least social cost in accidental events would be immensely important in convincing the country's population about the possible positive contribution of resorting to nuclear energy as an alternative energy source.
	• Adding Cross Border Interconnection of India and Sri Lanka.	Specific gender and social impacts related to these actions need to be studied and mitigated

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
Transport	• Promoting remote working	Travel is one of the most important ways of social interaction and maintaining social relations. The social cost of reducing travel could be highly unhealthy. This needs to be considered in planning
	• Promoting e-commerce and e-learning	• Lack of adequate internet coverage • High cost of data usage • Lower affordability of relevant devices will have a negative impact in promoting online work platforms. In e-commerce, the possible negative impact to the small-scale market-oriented activities due to the above factors should be considered. Learning capacity of the people concerned of necessary technology needs to be improved. In introducing e-learning, individual and family income and the internet coverage should be taken into consideration. Possibility of the learners to abuse the system and falling prey to various abusive and exploitative situations and also the learners becoming victimized due to uncontrolled usage of the system are common pitfalls that could be identified in e learning settings. As a solution sensitizing and improving the knowledge of adults including teachers and parents on various applications to monitor and control the internet access of learners, especially children would be highly necessary. Reduction of spatial movement often gives a feeling of incarceration and prevent imagination, creativity and liberal thinking.

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
		Expanding recreational facilities and improving facilities for travel for pleasure (considering the current high cost of travel) could be used in overcoming these negative impacts. Recreational facilities, housing/ quarters, for the working population and green city features would provide sustainable solutions
	• Attract private vehicle users to buses	Convenience to the user is decisive in making such a shift. Bus transportation system should be made orderly, efficient, courteous and convenient to the user.
	• Implementation of LRT network in Colombo	Cost of transportation should be decided considering the affordability of vulnerable populations.
	• Electrification of urban rail tracks • Decarbonisation of long-distance and freight rail with hydrogen fuelled engines • Introduce electric inter-provincial and provincial buses • Replace fossil fuel based private vehicles with electric vehicles • Introduce electric charging points and necessary infrastructure	The actions proposed would be socially beneficial as long as they meet the transportation needs of the ordinary population including low-income travellers and other economically vulnerable groups (pensioners, people with disabilities, and women) Special needs of the above mentioned categories need to be considered in designing and planning.
	• Congestion charging for selected zones to discourage vehicles entering during peak hours	Law enforcement in vehicle emission control. Any cost increase should not overburden vulnerable populations including female breadwinners, elderly, and people with disabilities.

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
	• Prohibit roadside parking, increase parking fees in cities	Shuttle systems to commute from parking places especially designed for old, disable, women and needy population.
	• Improve the pedestrian infrastructure on collector type roads in the country • Promoting cycling	Safe and smooth pavements for pedestrians to walk to short distances and trolleys for convenient shopping Women's clothing could interfere in cycling. Policy decisions on safe dress code is important
	• Implement a price formula for petrol and diesel to reflect global petroleum prices and exchange rates	When revising the public transportation charges according a price formula, the possible impact on low-income populations should be addressed.
	• Park and ride system at main corridors for vehicles entering the city	Introducing reasonable charging systems considering the affordability of daily users.
Industry		All sectors mentioned depend heavily on female population and designing any new measures to reduce carbon emission should consider their possible impact on female working population
	• Promote Resource Efficient Cleaner Production (RECP) practices	Giving concessions for small scale industries and cottage industries which are mainly driven by women and middle-income populations considering their affordability
	• Establish eco-industrial parks and villages	Promoting incorporation of a larger female worker population while considering gender equity as a fundamental premise in this process
	• Adopt the Circular Economy concept	Gender equity also need to be taken into consideration
	• Introduce tri-generation facilities	A social and gender analysis will be highly important in carrying out this study

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
	• Providing strategic direction, oversight, support and sufficient resources to set and achieve targets • Incorporating net zero targets into core governance documented information (e.g. national policies, action plans, regulations etc.,), • Disclosing stakeholder need information and records on climate-related issues, if appropriate to the country and net zero emission targets, • Publicly committing to achieve 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	Facilitate entry access to women Such policy and planning level revisions towards carbon net zero targets should be on par with national policy on women (still in the draft form). Gender equality in defining national and sub-level leaderships and also the inclusion of different stakeholder categories including vulnerable groups in decision making levels. In all decision-making bodies, it is highly necessary to have gender focal points and ensure all stakeholder groups are represented.

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
	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 further action needed	
	• Substituting clinker with other materials in cement production (Amendment Sri Lanka Standard Institute (SLSI) standards for cement production enabling the increase of ash and other similar materials as substitutes for clinker)	

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
	• Implement polluters pays principle	Identifying the actual polluter is extremely important
Waste	• Reduction of the waste amount at the source • Avoid & Reduce MSW generation Growth from source • Avoid & Reduce Wastewater generation Growth from industries • Introducing MSW Segregation categories, Improving waste collection and transportation problems • Improving laws, rules, and regulations and formulating economic measures to create motivation for waste reduction • Supporting deposit & refund systems for plastic bottles, glass bottles, Aluminium bottles, etc. • Encouraging entrepreneurs to reduce disposable waste container sales and promoting safe reuse containers • Promoting food waste separation at source, obviously after avoiding the waste as much as possible	At the outset, the central government as well as the local government authorities should lay out a systematic waste disposal plan that would convince people of the commitment of the relevant authorities. The most needed community support for the reduction of waste at various levels could more easily be sought after when the public could place trust on the authenticity of official commitment. Awareness raising among women on waste management imparting necessary knowledge on the subject. The management in all relevant sectors should be given the specific knowledge on the reduction of waste. It should be made an important segment of the sectoral management. Develop a local government-level strategic plan with the inclusion of relevant stakeholders and raising awareness among the local community on the waste production and disposal

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
	2. Promote recycling and use of recycled materials • Create awareness among industrialists that improve materials and material flows like reuse and recycling • Waste into reverse-engineered products • Mandate recycled content requirements and waste reduction measures	Programs to encourage communities to recycle and use recycled material, adopting measures such as providing incentives and promoting the use of low-cost recycle material
	3. Promote Circular Economy in Supply Chains • Boosting the energy and resource efficiency of products, addressing the presence of dangerous chemicals in them • Enhancing the number of recycled materials in products while maintaining their functionality and safety; facilitating remanufacturing and superior recycling • Limiting single-use and combating premature aging • Putting a stop to the destruction of durable items that have not sold	• Raise awareness among people about separating waste in the dangers that could have created during waste disposal processes. • Awareness raising campaigns in schools and communities and incorporate such programs into Community-based Organization (CBO) activities. • A system for purchasing and reusing such items. Competitive programs getting people involved in choosing/voting for the best sustainable products

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
	• Encouraging business models that allow producers to retain ownership of the product or accountability for its performance over its entire lifecycle • Products should be rewarded depending on their various sustainability performance • Design for deconstruction in such a way that the materials used for construction can be reused in new construction with minimum alterations	Business ventures to promote to recycle construction material and give adequate publicity to such businesses attracting public attention
	4. Efficient waste management • Supporting provincial administrative organization clustering to make waste management systems, reuse systems • Restrict outdoor burning and improve the operation of clean development mechanisms • Addressing the prevalence of microplastics in the environment • Establishing and standardizing	Establish village-level plastic collection centres/bins and raising awareness among women and school children. Efficient waste collection programs and effective community awareness programs Popularize alternative material

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
	measurement techniques for accidentally released microplastics, particularly from tires and textiles	
	5. Biochar used as carbon sequestration • pyrolyzing conversion of solid waste into biochar which supports the circular economy • Introducing biochar as a renewable energy resource such as carbon fuel cells, porous catalysts, bio-oil, biochar coal, syngas, etc.	Make renewable energy resources and necessary equipment available for easy access in the market for household use
	6. Hybrid fertilizer Production • Redirect MSW away from landfills so that it can be used as a supplement to fertilizer on agricultural fields so, aiding in preserving soil fertility and recycling trash • Combine Agricultural compost with MSW compost	Introduce programs for promoting the use of fertilizer produced out of MSW in market oriented and household agriculture
	7. Identifying the waste management activities and the emissions reduction opportunities that	Receive public support in identifying practical and sustainable waste management activities while benefiting from indigenous knowledge in reducing carbon emissions in everyday activities

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
	can be implemented in Sri Lanka • 3R practice as well as saving money, energy, and natural resources related to life cycle management • Introduce strategies on the national level to build an economy that keeps materials, products, and services in circulation for as long as possible	Implementing awareness raising programs at different levels in the community (schools, CBOs, and higher educational institutions) In national-level planning for a cleaner economy, inclusion of women at the planning level would be highly beneficial
	8. Promoting zero-carbon innovations • Offering National Research Grants for Zero Carbon innovations • Introducing zero-carbon building materials • Introduction of Carbon Adsorbing Materials	Adopting Participatory Research Appraisal (PRA) methods in research projects concerning such new products
Agriculture	• Choosing management practices that enhance productivity • Extending lactation periods of dairy cows; • Using more efficient breeds • Improving reproductive performance; and	Imparting necessary knowledge on methods proposed under this measure to the population involved with the sector, especially to women and younger generations who could be a massive resource pool. Patriarchal domination in the agricultural sector often does not allow women to become decision makers concerning utilization of new methods. Therefore, consultations at the ground level using

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
	• Increasing rates of gain in beef animals so they reach the market sooner	participatory approaches would be important in promoting not only the inclusion of women in decision making, but also deriving indigenous knowledge that can be integrated in moving into new systems
	• **Effective Land management practices** ▪ Reduction in tillage. ▪ Restoring degraded land, improving pasture management. ▪ Reducing fallow periods. ▪ Adding animal manures to the soil ▪ Crop residue management ▪ Using legumes and/or grasses in crop rotations. ▪ Converting marginal cropland to perennial grass or agroforestry systems ▪ Using rotational grazing and high-intensity/short-duration grazing. ▪ Planting shrubs and trees as shelterbelts. ▪ Restoring wetlands	In implementing all these activities, community involvement and support would be highly beneficial to ensure effective results. In gaining community support, the programs need to include visible short-term and long-term benefits to the community.

Sector	Proposed Actions in Carbon Net Zero Roadmap	Gender and Social Impact and possible Mitigation Measures to the Impending Problems
Forestry	• Establish new forests (afforestation) • Restoration and reforestation	Increased women's involvement in identification and implementation process. Achievable through women's societies and CBOs on a voluntary basis and could provide a leisure activity for women without overburdening them
	• Protection of existing natural forests and forest plantations	Inclusion of local communities and women in developing sustainable management of natural forests. Incorporate indigenous knowledge in the planning process Inclusion of local communities and women in all these activities from planning to implementation Awareness raising of the communities and the involvement of Community-based Organizations is highly important Community consultations with affected communities could be used as a major tool in identifying and prioritizing hazards and their impacts
	• Increase the contribution of trees outside forests	Awareness raising among all groups such as local communities, religious congregations, school children and getting their involvement and participation at various levels of the process
	• Increase blue carbon ecosystems such as mangroves, seagrass beds and salt marshes	Benefit from the interest and knowledge women have about their local surroundings in coastal areas in restoration of mangroves Incorporate in the school curriculum and local schools could be integrated in the entire process as part of their field-based studies giving stake to local communities in the process

4.8 Issues and Constraints and Policy Gaps on Achieving Net Zero Status of Sri Lanka

4.8.1 Energy Sector

Successful decarbonization of the energy sector would require alignment of the political and economic forces in a productive manner. In order to support the rapid development of nuclear energy, certain regulatory requirements have to amended. At present the Sri Lanka Atomic Energy Regulatory Council is empowered only for regulation of non-power uses of radiation. Furthermore, development of a firm Government policy is required for the consideration of Nuclear Power as a power source in the future energy mix. Establishment of a Nuclear Energy Programme Implementing Organization (NEPIO) or any other responsible organization is required for the future study/planning activities of the nuclear power programme in Sri Lanka. Following options can be considered to implement regulatory requirements.

- Promulgation of a new Act and Establishment of a new regulatory body with adequate human and other resources for regulation of Nuclear Power Plants.
- Amendment of the existing Sri Lanka Atomic Energy Act No.40 of 2014 to include regulation of nuclear power and strengthen the manpower and other resources

A clear and strong policy directive is necessary in the nuclear energy sector (similar to government no-coal policy) to incorporate nuclear power as mainstream scenario in the LTGEP.

Knowledge of alternative technologies have been increasing in recent years through increased awareness of climate change. However, there is still a significant lack of knowledge regarding low-carbon technologies compared to traditional fossil fuel heating systems among the policy makers, administrators, officers and general public. Industry skills must incorporate a holistic approach to ensure an efficient installation without unintended consequences. Therefore, it is essential to build a competent workforce capable of designing, building, and retrofitting to deliver energy efficient, net zero carbon systems in the energy sector.

Sri Lanka's potential for cross border energy trade lies with its immediate neighbor, India. The proposal for bilateral energy trade has centered around the proposed India-Sri Lanka High Voltage Direct Current (HVDC) grid interconnection project, aimed to link the national grids of India and Sri Lanka. However, the viability of the project has come under scrutiny on the basis of the limited potential for electricity trade and the high cost that may be incurred in terms of the infrastructure. Public-private partnership (PPP) can be a way forward to move this type of project, where certain amendments to be made to the present electricity act.

Therefore, the willingness at the political level backed by robust analysis is expected to move the aspiration towards faster actions to meet this ambitious, yet achievable target. There are many interesting aspects related to the political economy that must be anticipated and responded to in a strategic way. These include loss of fiscal resources for fossil-dependent states, loss of revenue for certain agencies such as Lanka Coal Company, Ceylon Petroleum corporation and other associated agencies. Dealing with entrenched interest groups and labour unions is expected to be a major political economy challenge that Sri Lankan policymakers would need to face for a net zero transition in the energy sector.

As finance accessibility and sufficiency are among the key challenges for carbon net zero in energy sector, particularly the widespread deployment of RE and other clean energy deployments, it is essential to explore the different and innovative financing schemes and sources available to facilitate such developments. The lack of knowledge and capacity in the sector including the local financial institutions on new opportunities such as Green Financing. is one of the key constraints in the energy sector.

Lack of long-term, consistent, and effective policy and regulation, which exists to drive the energy sector to net zero is the centrepiece of the gaps in policy. The Government and Industry must work together to setting out the policies and programmes required with realistic timescales for implementation, which drives the sector to achieve Net-Zero target. Therefore, there is a need in energy sector for a comprehensive appraisal of the policy and regulatory environment (both sectoral and crosscutting) and introducing relevant revisions in the related policy elements to achieve the Net-Zero target.

Some of the key general and specific areas that should be considered include: (i) Ensuring proper assessment and monitoring of related policy implementations; (iii) Eliminating regulatory barriers and streamlining the associated processes; (iii) Introducing clear policy directives and guidelines on RE resource allocations, speedy project approval procedures for clean energy; (iv) proper and consistent process for RE and other clean energy procurement in power sector; (vi) Introducing power wheeling schemes, particularly for RE.

It is necessary to establish a platform for the market by proposing and implementing standardised market integration and transparency frameworks that facilitate competitive markets. Further, establishment of formal market-based trading arrangements, supported with harmonized and coordinated commercial, regulatory, and legal framework, is required to realize set targets in energy sector. Furthermore, shift from a single buyer to a wholesale model or retail competition for the power sector and electricity trade, is also identified as a policy gap in the energy sector.

4.8.2 Transport Sector

Policy issues

Policy-wise, the transport sector is significantly lagging behind other sectors. There is no national policy for the transport sector of the country, that will guide the strategies and projects that are to be implemented. The draft National Transport Policy which is under review since 2019 needs to be finalized soon and gazetted.

Often, projects on an ad-hoc basis are considered due to the lack of finance available with the government for transport infrastructure development. As a solution, like many other countries, public-private partnerships (PPP) are brought into the discussion. However, the capacity building (amongst relevant state institutions), regulatory and legal requirements, and accurate information availability with respect to costs/demand projects that are necessary for successful PPP implementation have not materialized in the transport sector.

In addition, the integration of transport-related organizations' national development plans is also essential since some individual organizations' decisions might affect the transport needs of the users directly. For example, decisions taken by the UDA on land use changes affect the transport needs of the people in the surrounding area. Thus, with a broader level of consultation of all stakeholders, the development of a national transport plan is key to achieving the objectives of this project. One positive development in this regard is the formation of one ministry, 'Ministry of Highways and Transport' that includes all the major transport sector stakeholders.

Financing

The estimated financial cost of the proposed initiatives is likely to exceed US $ 6-7 bn over 20 year period. Not only that there would be additional fund requirements for operations and maintenance. The government's fiscal capacity to invest at this magnitude must be evaluated considering the other economic issues in the country.

Data Availability

Major shortcoming is the lack of transport sector data including accurate vehicle-kilometer estimation for private vehicle modes at national and provincial levels. Moreover, the trip characteristic data such as trip purpose, mode choice distribution based on passenger kilometers at national level would be useful.

The active vehicle fleet in the country also needs to be accurately estimated, the current data includes the vehicle registrations (cumulative) and the revenue license issued which can be used to estimate the active fleet as a percentage of the total registered vehicles.

The emission levels of different types of vehicles should be accurately evaluated using the Vehicle Emission Test Data and additional validation studies to determine how specific taxing instruments can be implemented to discourage vehicles with poor emission related performances in the long term.

The initiative taken by the National Transport Commission to publish annual report with transport statistics is an encouraging sign, this should be further improved with expanding the data collection and analytics and providing an online tool to access the data.

4.8.3 Industry Sector

Issues and constraints relevant to achieving proposed targets in the industry sector will be analyzed through the following areas (but not limited to) and remedial measures will be proposed.

Immediately recognized issues and constraints relevant to achieving industry net zero targets are as follows:

- Industry sector Policy issues/gaps

    - Lack of national industry umbrella policy
    - Though some of the existing policies as mentioned in Section 1.4.3 are highly relevant to the industry sector emission reductions, due to long term negligence and lack of updates with respect to climate change mitigation needs, there are major gaps in the policy environment (Ex National cleaner production policy).
    - In addition to the existing policies, as Circular Economy is one of the main bridging strategies between climate net zero mechanism and sustainable development, especially in the industry sector, national circular economy policy and action plan covering all national economic sectors will be a major policy need. Though certain policies such as "national policy and strategy on sustainable development" are still given low priority to finalize (since 2019 it is in draft stage). Under the prevailing economic crisis, it will be worth in considering the sustainability opportunities behind these emission mitigation issues (Ex. Optimising the glass cullet recycling in national glass industry and glass industry process emission reduction).
    - In addition to the policy gaps, unavailability of a national action plan based national MRVU (monitoring, reporting, verification and update mechanism) is proposed as a major gap in national climate change responses.
- BOI industry policy (with a priority on investment promotion and economic development concerns rather than promoting low-carbon industry proposals)
- Lack of sustainability guidelines in setting up individual industry/industry parks with appropriate sustainable economic analysis and incentives to promote the low-carbon industry,
- National-level recognition of low-carbon industries and their sustainability impacts
- Lack of promoting/attracting low carbon options such as Co-generation / tri-generation, district heating/cooling, and benefits
- Availability of Resources
- Institutional constraints
- Technology/ knowledge

4.8.4 <u>Waste Sector</u>

There are several issues and constraints in achieving the targets and the primary issue would be the unavailability of a centralized data management system which is common for all the responsible authorities. Meanwhile, the so-called database should be organized in such a way that the data are updated in real-time and open to the public, and researchers which enables continuous research with the relevant data.

Moreover, there is no proper waste management and whatever is available is planned and implemented weakly which can be further expedited. There is a lack of commitment by all parties concerned lack of financial resources/assistance and a lack of public awareness. Also, there is a lack of Political will & conflicts of local level politics and a lack of Institutional capability with technical expertise. Unavailability of Suitable lands for waste disposal, weakness of collection system, no proper collection system of recyclable waste, haphazard dumping of SW in unsuitable locations e.g. roadsides, wildlife protected areas Wetlands, flood retention areas, water courses, and no proper environmentally sound waste disposal practices are few issues for MSW disposals.

Furthermore, paying the least attention to SW problems in the majority of LAs, legal provisions and role designation, the overlap of administrative functions at national, regional, and local levels, Outmoded laws and regulations, the weak or total absence of monitoring by civic authorities / civil society and public apathy are some issues where more attention is needed. Medical issues such as health issues (stray dogs, breeding grounds for mosquitoes and flies)and Loss of aesthetic values & scenic beauty, water pollution (both surface and ground water)through leachate and run-off, air Pollution by dioxins, particulates, and hydrocarbon combustion emissions by open burning due to incomplete, odor problems and open dumping of biomedical wastes could cause epidemics.

The ever-increasing demand for land required for solid waste disposal, and the uncontrolled release of landfill gases from dumps and non-engineered landfills are concerning issues. Currently, MSW is disposed of together with hazardous waste, biomedical/ health care waste etc., (Mixed waste) creating huge health and environmental issues and the provision of infrastructure facilities and suitable lands are the main requirements of Local Authorities for integrated solid waste management practices.

While the existing policies, strategies and action plans related to the waste sector, as described in section 1.4.1 aimed at environmental pollution control does help in the actions for reduction of GHG emissions to some extent, there are specific policy instruments that are needed to achieve national net zero targets with the community and institutional involvement. These were identified as gaps during the discussions with the stakeholders at the two meetings held with sector stakeholders.

Policy gaps identified during the 1st stakeholder meeting

1. The National Waste Management Policy should be amended to
    - Improve the segregation of MSW at source and increase the number of segregation categories
    - Clearly define the purpose of waste-to-energy projects and plan the phasing out of preferential feed-in-tariffs
    - Introduce other thermal treatment technologies
    - Introduce Land-fill Gas recovery systems
2. Policies should be introduced to regulate the establishment of new waste-to-energy facilities
3. Operationalize policy and regulation for siting and implementation of sanitary landfills
4. Update or introduce the required legislation to facilitate and enforce the implementation of NDCs

5. Introduce a mechanism for waste generation forecasting with a tracking system to monitor the generation
6. Introduce legislation to make segregation of waste at the household level mandatory
7. Introduce or amend necessary legal framework and instruments to initiate Market-Based Instruments (MBIs) and non-market-based instruments to incentivize and promote sustainable consumption patterns
8. Implement the "Polluter Pays Principle" for mixed waste generators
9. Conduct awareness and capacity-building programs for behavioral changes in waste generators as well as waste management personnel
10. Facilitate public-private-partnerships to finance waste sector mitigation actions

At the second stakeholder meeting, in addition to the gaps in national policies, the following were identified as gaps that need to be addressed for the successful implementation of the mitigation actions proposed for achieving Carbon Net Zero status:

- Staff training
- Availability and access to technology
- Infrastructure
- Institutional framework
- Financial constraints
- Administrative issues
- Research needs
- Baseline data needs
- Future Data gathering mechanisms
- Need for local technology development & transfer of technology

4.8.5 Agriculture Sector

The project plans to establish a Road Map and a Strategic Plan with the acceptance of all concerned stakeholders on its effective and meaningful implementation while developing set of policy guidelines anchored on the strategic plan collaborating all levels of the administrative entities of the Government of Sri Lanka. Further to that, country is planning to achieve the balance between the amount of carbon produced and the amount removed from the atmosphere or activity that releases net-zero carbon emissions into the atmosphere by primarily reducing its emissions of greenhouse gasses into the atmosphere and increase its carbon dioxide-absorbing ecosystems. Climate Analysis Indicators Tool published by the World Bank (WRI CAIT), Sri Lanka's GHG profile in 2011 was dominated by the energy sector (40%), followed by the waste (28%), land use change and forestry (LUCF) (15%), agriculture (14%) sectors and transport sector (20%).

i. Policy issues

If the targets set by the National Agriculture Policy by 2030, it means that resources productivity and economic profitability would increase by 100% and it is comparable to section 2 of the NDC 2030, where it stresses the importance of identifying crops/ varieties with high productivity, adopting good agricultural practices (GAP), increasing the land use productivity, improving fertilizer use-efficiency, improving water use efficiency and promoting precision agriculture. Further, the policy goals set target to increase technology adoption and high quality and high yielding seed and planting material production by 50%.

However, the institutions responsible for such achievements in agriculture mentioned at the First Stakeholder Workshop held on 23rd October 2022, that there are still policy gaps in following NDC 2030 activities.

Institution	Activity	Policy gaps for sub activities
Department of Animal Production and Health	Improve adoption of renewable energy in agriculture	Application of solar power and wind energy Promote grid electricity use
	Adopt renewable energy for livestock applications	
Coconut Cultivation Board	Increase crop productivity	Increase land use productivity Improve fertilizer use-efficiency Improve water use efficiency

At the Second Stakeholder Workshop held on 18th November the Ministry of Agriculture reiterated that although they have resources (finances, manpower, technical knowledge) those are not adequate to review the present policy by 2025. They also have constraints such as lack of coordination among institutions, complexity, and lack of awareness within institutions. They need the support of International Organizations (FAO, UNDP, JICA, and WFP etc.), NGOs, and other organizations such as RRI, CRI, TRI, CCB, DOA, DAD, DEA etc.

Ministry of Livestock Development has also expressed the same concern on resources availability and they also need support of other institutions such as NLDB, Research Institutes, MILCO, Provincial DAPH, Irrigation Dept., Mahaweli, Universities etc.

Ministry of Irrigation and Ministry of Land are responsible for the review of the policy on Irrigation, Land Use and make recommendations to minimize GHG emissions. These Ministries can review the policies by 2025 but they are constrained with resources such as finances, manpower, technical knowledge etc. Supporting agencies are CEA, UDA, Ministry of Environment and they need further support from NBRO and Universities.

ii. Availability of Financial Resources

Some institutions had to curtail their programmes due to restrictions of annual budgetary allocations. Without any external support some programmes would not be possible to implement. However, certain projects support institutes to continue their programmes. This resources constraint has been brought up by the institutes at the first stakeholder workshop of the Carbon net zero project as follows.

Institution	Activity	Financial Constraints for sub activities
Department of Agrarian Development	Improve adoption of renewable energy in agriculture	Promote grid electricity use
Department of Animal Production and Health	Improve adoption of renewable energy in agriculture	Application of solar power and wind energy Promote grid electricity use
Coconut Cultivation Board	Increase crop productivity	Adopt GAP Increase land use productivity Improve fertilizer use-efficiency

iii. Institutional constraints

Main institutes working on NDC undergo several constraints that hinder the success of achievements especially policy gaps, staff, infrastructure and proper technologies. However, the institutes that responded seem to be having not much institutional constraints. As stated by institutions at the 1st Stakeholder Workshop, following institutional constraints for achieving NDC 2030 are faced by them.

Institution	Activity	Institutional constraints for sub activities
Department of Agrarian Development	Reduce post-harvest losses and value addition	Cultivation management Post-harvest management Excess production management
	Improve adoption of renewable energy in agriculture	Promote grid electricity use
Department of Animal Production and Health	Improve adoption of renewable energy in agriculture	Application of solar power and wind energy Promote grid electricity use
Coconut Cultivation Board	Increase crop productivity	Increase land use productivity Improve fertilizer use-efficiency Improve water use efficiency

iv. Technology/ Knowledge

Proper technology, available knowledge base and effective dissemination process are constraints of some institutes in the agricultural sector in achieving NDC goals. It stresses the importance of capacity building for these institutions. This was brought up at the 1st Stakeholder Workshop.

Institution	Activity	Technology/ knowledge requirement for sub activities
Department of Agrarian Development	Improve adoption of renewable energy in agriculture	Promote grid electricity use
Department of Animal Production and Health	Improve adoption of renewable energy in agriculture	Application of solar power and wind energy Promote grid electricity use
Coconut Cultivation Board	Increase crop productivity	Increase land use productivity Improve fertilizer use-efficiency Improve water use efficiency

Productivity of agricultural crops can be increased through Good Agricultural Practices, increasing land use productivity of paddy lands, increasing soil fertility of crop lands, increasing water use efficiency in crop production, integrated farming systems, intercropping and agro-forestry systems approach. However, Agencies such as MoA, MPI, DoA, DEA, EDB are in the opinion that they do not have adequate resources such as finances, manpower, technical knowledge for successful implementation.

Another strategy is to promote crop diversification. Again responsible agencies such as DOA, DEA, Private Sector Organizations and EDB express their concern on inadequacy of resources such as finances, manpower, and technical knowledge for implementing the Carbon Net Zero approach.

As policymakers look toward including strengthened agriculture actions in an enhanced NDC, it is important that they first lay the foundation through enhanced policies, finance, and governance. Doing so will help ensure that proposed mitigation actions are tailored to the country's unique set of circumstances and needs and are aligned with a broader set of food security, equity, and sustainable development imperatives, thus maximizing the chances of successful implementation. This includes the following:

- Scoping the national context – As spatial variability across the country on geography, economy and social aspect, any Carbon net zero should avoid a blueprint approach and carefully consider key characteristics of a country's agriculture sector. This considers national production and consumption trends of crops and livestock, as well as the types and sizes of producers.
- Involvement of Stakeholders – Involving stakeholders even at the beginning to strengthen the legitimacy, quality, and durability of the Carbon net zero targets of 2050. Stakeholders include not only relevant government ministries but also farmers, so that diverse perspectives, needs, and priorities are incorporated. Small-scale agriculture producers, especially women and women's organizations, should be explicitly included, which requires targeted and sustained attention from policymakers. Likewise, it is important to engage stakeholders that will be responsible for the implementation of agricultural climate action.

- Establishing policy coherence – Sri Lanka can consider progress made toward implementing existing goals and policies, and their coherence with other relevant plans, including other climate policies.
- Strengthening measurement, reporting, and verification – In the agriculture sector planning for mitigation, adaptation, and support is foundational for designing C net zero targets. Updated information base provides accessible, understandable, relevant, and timely information and data to inform the design of new climate targets and policies. It deepens the understanding about actions to address climate change to discern what works, what does not, and why. Such effort can also be a useful communication tool for motivating climate change action, both within government and among external stakeholders.
- Identifying opportunities for support – Sri Lanka requires support to fully implement agricultural contributions to achieve C zero targets. This includes access to international climate finance, as well as local support such as improved extension services for farmers, including more widespread use of digital services such as early warnings and seasonal forecasts, and redirecting agricultural support to improve agricultural resilience and reduce emissions. The net zero enhancement process offers an opportunity to identify needs and attract support.
- Ensuring equitable, inclusive governance – It is important to anticipate whether and how proposed activities benefit or harm lives and livelihoods when advancing agricultural climate action. Careful design of incentive structures and finance flows can help facilitate equitable benefit sharing, while safeguard measures and rights-based approaches can help minimize harms.

Following specific aspects are also required to be considered:

1. Settlement policy to manage available land for future human settlements enabling release of more land for cultivation and reforestation. (Gunasena, 2020)
2. National water resource policy to enrich groundwater resource in agricultural lands to enable integrated water resources facilitating the intensification of agriculture on existing lands discouraging opening up of new lands for agriculture and improve agro-ecosystems, while increasing bio-diversity;
3. Development of shallow groundwater to support not only deep-rooted vegetative systems but also encourage shallow rooted bushy type vegetation. Ultimately, this will enhance the entire biodiversity of Sri Lanka and will contribute to carbon sequestration positively. Hence, development of a policy initiative for groundwater recharging will enhance the utilization and replenishment efficiency of surface and subsurface water resources;
4. Policy initiatives to establish fruit gardens and medicinal plant gardens for reforestation activities to safeguard vanishing native fruits and medicinal species while managing above and below soil carbon stocks;

5. It is very clear now that the vegetation of central highlands becomes sparse due to lack of soil carbon stocks and depleting groundwater table. Most of the first order streams within plantations are drying and have been already converted from perennial to seasonal. Therefore, policies must be formulated to establish a Hydrology Unit or section or laboratory in all major plantation research institutes (Tea, Rubber, Coconut etc.) to regain the lost groundwater balance from the central hills; and
6. According to statistical evidences, Sri Lanka is having nearly 5,100,000 families, and most of the families will have land plot having at least 0.3 hectares. Most of the land areas belonging to these families consist of a live fence. Country wide development program could be implemented to upgrade these fencing systems to a fencing ecosystem having fruits, timber and medicinal plants, which need less fertilizer. Necessary policy initiatives must be formulated to establish these live fences wherever possible to increase the carbon sequestration process.
7. Necessary policy initiatives must be drafted and formulated to get the maximum contribution from the Sri Lankan inventors to overwhelm the technology barriers. A comprehensive problem database must be developed with the participation of Sri Lanka Inventors Commission (SLIC) enabling all entrepreneurs to feed their technical problems to a government managed web base/ database, while allowing local and foreign inventors to find those problems and provide appropriate solutions to the burning technical problems. This will boost the agricultural and industrial sectors in Sri Lanka within a short period of time with cost effective local technological solutions.

Most of the development programs were planned by the government or nongovernmental organizations with minimum community participation. Since the community is responsible for the implementation and monitoring of almost all these development plans, the responsibility must be shared with the community to manage the sustainability by blending those programs with the ecosystem services and the resilience of all ecosystems. Hence, necessary policy initiatives must be formulated to bring the appropriate management systems and blend with the community participation appropriately.

4.8.6 <u>Forestry Sector</u>

In order to reach the targets for emission control and enhanced sequestration of carbon, it is essential that the necessary environment and infrastructure are available. Following issues are some of the constraints envisaged to be barriers to achieving the set targets in the sector:

- Sub optimal availability of lands for reforestation/afforestation and land for such purposes are constantly competing with the other non-forest land uses

- The actual implementation on the ground does not follow the plans including National Physical Plan and therefore the areas allocated for forests do not materialize on the ground sometimes

- With regards to trees outside forests and mangroves which provides a significant contribution for carbon sequestration, there are many policy and regulatory gaps, death of institutional responsibilities etc.

- Climate change with special reference to drought which adversely impact the forests

- River catchments and reservations are not in place and mostly used for agricultural practices

- Lack of political will, financial resources, manpower and technology for implementation of mitigation actions.

SECTION 5 : CARBON NET ZERO ROAD MAP

5.1 Pathway for achieving Net-Zero Carbon emissions by 2050

Implementation of strategies and actions set out in Section 4 of this report for the six sectors Energy, Transportation, Industry, Waste, Agriculture and Forestry according to the planned program would drive the country towards achieving Carbon Net Zero status well before 2050, if the necessary policy framework, good governance, funding, infrastructure and institutional set up is provided in a timely manner. This section summarizes the pathways for emission reduction and increased sequestration over the period 2025 to 2050 that need to be followed sector wise, and the lead agencies that should take the responsibility for the implementation of actions.

5.1.1 Energy Sector

Table 5.1: Five year Interval Plan in Energy Sector for Option 1 (With Nuclear PP)

Period	Mitigation Action		Responsibility
2025-2030	Adding following Power Plants for Power Generation		
	Pumped Storage	700 MW	MoPE/CEB
	Mini Hydro	135 MW	MoPE/CEB/SLSEA
	Biomass	120 MW	MoPE/CEB/SLSEA
	Wind	1390 MW	MoPE/CEB/SLSEA
	Solar	3015 MW	MoPE/CEB/SLSEA
	Battery Energy Storage	725 MW/2900 MWh	MoPE/CEB
	Retirement of following Thermal Plants for Power Generation		MoPE/CEB
	Diesel	437.4 MW	
2031-2035	Adding following Power Plants for Power Generation		
	Pumped Storage	700 MW	MoPE/CEB
	Mini Hydro	50 MW	MoPE/CEB/SLSEA
	Biomass	90 MW	MoPE/CEB/SLSEA
	Wind	800 MW	MoPE/CEB/SLSEA
	Solar	2420 MW	MoPE/CEB/SLSEA
	Battery Energy Storage	675 MW/ 2700 MWh	MoPE/CEB
	Nuclear	2x300 MW	MoPE/CEB/ SLAEB
	Adding Cross Boarder Interconnection	500 MW	MoPE/CEB
	Retirement of following Thermal Plants for Power Generation		
	Diesel	191.7 MW	MoPE/CEB
	Diesel/Natural Gas	398 MW	MoPE/CEB

Period	Mitigation Action	Responsibility
	Introduction of Green Hydrogen	SEA/PRDS
2036-2040	Adding following Power Plants for Power Generation Mini Hydro 40 MW Biomass 50 MW Wind 750 MW Solar 2650 MW Battery Energy Storage 515 MW/ 2060 MWh Nuclear 1000 MW Retirement of following Thermal Plants for Power Generation Diesel 300 MW	 MoPE/CEB MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB MoPE/CEB/ SLAEB MoPE/CEB
2041-2045	Adding following Power Plants for Power Generation Biomass 120 MW Wind 950 MW Solar 2830 MW Battery Energy Storage 625 MW/ 2500 MWh Retirement of following Thermal Plants for Power Generation Coal 900 MW	 MoPE/CEB MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB MoPE/CEB
2046-2050	Adding following Power Plants for Power Generation Biomass 150 MW Wind 1300 MW Solar 3150 MW Battery Energy Storage 625 MW/ 2500 MWh Adding Cross Boarder Interconnection 500 MW Retirement of following Thermal Plants for Power Generation Diesel/Natural Gas 895 MW	 MoPE/CEB MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB MoPE/CEB SEA/PRDS

Table 5.2: Five year Interval Plan in Energy Sector for Option 1 (Without Nuclear PP)

Period	Mitigation Action	Responsibility
2025-2030	Adding following Power Plants for Power Generation Pumped Storage 700 MW Mini Hydro 135 MW Biomass 120 MW Wind 1390 MW Solar 3015 MW Battery Energy Storage 725 MW/2900 MWh Retirement of following Thermal Plants for Power Generation Diesel 437.4 MW	 MoPE/CEB MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB MoPE/CEB
2031-2035	Adding following Power Plants for Power Generation Pumped Storage 700 MW Mini Hydro 50 MW Biomass 90 MW Wind 1200 MW Solar 3350 MW Battery Energy Storage 850 MW/ 3400 MWh Adding Cross Boarder Interconnection 500 MW Retirement of following Thermal Plants for Power Generation Diesel 191.7 MW Diesel/Natural Gas 398 MW Introduction of Green Hydrogen	 MoPE/CEB MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB MoPE/CEB MoPE/CEB MoPE/CEB SEA/PRDS
2036-2040	Adding following Power Plants for Power Generation Mini Hydro 40 MW Biomass 50 MW Wind 2050 MW Solar 4700 MW Battery Energy Storage 1175 MW/ 4700 MWh Retirement of following Thermal Plants for Power Generation Diesel 300 MW	 MoPE/CEB MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB MoPE/CEB
2041-2045	Adding following Power Plants for Power Generation Biomass 120 MW Wind 2050 MW	 MoPE/CEB MoPE/CEB/SLSEA

Period	Mitigation Action	Responsibility
	Solar 4550 MW Battery Energy Storage 1140 MW/ 4560 MWh Retirement of following Thermal Plants for Power Generation Coal 900 MW	MoPE/CEB/SLSEA MoPE/CEB MoPE/CEB
2046-2050	Adding following Power Plants for Power Generation Biomass 150 MW Wind 2800 MW Solar 3300 MW Battery Energy Storage 825 MW/ 3300 MWh Adding Cross Boarder Interconnection 500 MW Retirement of following Thermal Plants for Power Generation Diesel/Natural Gas 895 MW	 MoPE/CEB MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB MoPE/CEB SEA/PRDS

5.1.2 Transportation Sector

Table 5.2: Five year Interval Plan in Transportation Sector

Year	Actions	Responsible Organizations
2025-2030	Improve the pedestrian infrastructure on collector type roads in the country Construct cycling infrastructure island wide	Urban Development Authority, Road Development Authority, Provincial Road Development Authorities
	Promoting remote working	Ministry of Labour, Ministry of Finance, Ministry of Public Administration
	Modernizing the bus fleet* (up to year 2040)	Ministry of Transport
	Implement a price formula for petrol and diesel to reflect	Ministry of Finance, Ministry of Power and Energy

Year	Actions	Responsible Organizations
	global petroleum prices and exchange rates Transport Demand Management Strategies in Key Cities Implementation of LRT network in Colombo Railway Electrification KV line- Padukka Interprovincial Bus Electrification 10% of the Interprovincial buses electrified Provincial Bus Electrification None	 Local government agencies, Urban Development Authority Ministry of Transport Ministry of Transport Ministry of Finance, Ministry of Transport, National Transport Commission Ministry of Finance, Ministry of Transport, National Transport Commission
2031-2035	Railway Electrification Coastal line- Kaluthara Interprovincial Bus Electrification 20% of the Interprovincial buses electrified Provincial Bus Electrification None Private and Freight Vehicles Electrification (Equivalent to vehicles imports in 2018*1.25)	Ministry of Transport Ministry of Finance, Ministry of Transport, National Transport Commission Ministry of Finance, Ministry of Transport, National Transport Commission Ministry of Transport, Ministry of Finance
2036-2040	Railway Electrification Puttalam line- Ragama	Ministry of Transport

Year	Actions	Responsible Organizations
	Interprovincial Bus Electrification 50% of the Interprovincial buses electrified Provincial Bus Electrification 10% of the Bus Fleet Private and Freight Vehicles Electrification (Equivalent to vehicles imports in 2018*1.5)	Ministry of Finance, Ministry of Transport, National Transport Commission Ministry of Finance, Ministry of Transport, National Transport Commission Ministry of Transport, Ministry of Finance
2041-2045	Railway Electrification Main line –Polgahawela Interprovincial Bus Electrification 75% of the Interprovincial buses electrified Provincial Bus Electrification 30% of the Bus Fleet Private and Freight Vehicles Electrification (Equivalent to vehicles imports in 2018*1.75)	Ministry of Transport Ministry of Finance, Ministry of Transport, National Transport Commission Ministry of Finance, Ministry of Transport, National Transport Commission Ministry of Transport, Ministry of Finance
2046-2050	Railway Electrification Northern line – Polgahawela Interprovincial Bus Electrification 100% of the Interprovincial buses electrified Provincial Bus Electrification 100% of the Bus Fleet	Ministry of Transport Ministry of Finance, Ministry of Transport, National Transport Commission Ministry of Finance, Ministry of Transport, National Transport Commission Ministry of Transport,

Year	Actions	Responsible Organizations
	Private and Freight Vehicles Electrification (Equivalent to vehicles imports in 2018*2)	Ministry of Finance

5.1.3 Industry Sector

Table 5.3: Five year Interval Plan in Industry Sector

Year	Actions	Responsible Organizations
2025-2030	Application of Cleaner production technologies in maximising productivity and the industry efficiencies and minimizing industry losses / waste	Relevant industries / private sector Ministry of industries Ministry of environment / Climate change secretariat BOI IDB Technology service providers Forest Department NGOs and multilateral donor agencies Private sector forest projects
2031-2035	Emission offsetting (by 25%) through forestry projects	
2036-2040	Emission offsetting (by 25%) through forestry projects and CCS projects	
2041-2045	Emission offsetting (by 25%) through forestry projects and CCS / CCUS projects	
2046-2050	Emission offsetting (by 25%) through forestry projects and CCS / CCUS projects	

5.1.4 Waste Sector

Table 5.4: : Five-year Interval Plan in Waste Sector

Year	Actions	Responsible Organizations
2025 – 2030	Daily cover for open dump site with Biochar (Continues until 2050) Expected GHG reduction, In 2026 – 70MT CO_2 – eq	SLLDC WMA-WP LAs

Year	Actions	Responsible Organizations
	In 2050 – 164MT CO_2 – eq	
	3R practice collection and reduction of waste generation at source. These practices are extended from NDC and improved to continue until 2050 Expected GHG reduction, In 2026 – 1.56 MT CO_2 – eq In 2050 – 6.60 MT CO_2 – eq	NSWMSC SLLDC WMA LAs
	Refunds & incentives for proper waste management	LAs
	Promote circular economy in supply chains	SLSEA SLAMERP SLAEA UNDP WMA
	Efficient waste management	LAs
	Hybrid fertilizer production and Subsidy free community-based composting	NSWMSC SLLDC WMA LAs
	Biogas from fecal sludge at community level	LAs BOI
	Introducing the waste management activities and the emissions reduction opportunities	LAs
2031-2035	Recovery of GHG from Open dumpsite to use it for the production of Syn Gas (Synthesis Gas) The implementation level begins at 10 % by 2031 and to be improved to 50 % by 2050 Expected GHG emission reduction In 2031 – 72 MT CO_2 – eq In 2050 – 738 MT CO_2 – eq This process to be continued until 2050 and beyond	NSWMSC SLLDC WMA LAs Private sector
2036-2040	Implementing a centralized Vertical Sub Surface Flow Constructed Wetland (VSSFCW) at a strategic location in the Western province to purify the wastewater biologically and re use the water to enrich the groundwater. Expected GHG emission reduction In 2036 – 4.6 MT CO_2 – eq In 2050 – 4.3 MT CO_2 – eq	CEA LAs CMC BOI Private sector

Year	Actions	Responsible Organizations
	Implementation of Electric vehicle for waste transportation and Route Optimization using Internet of Things (IoT) The vehicles to be charged with renewable energy. Expected total GHG reduction by 2050 1.5 MT CO_2 – eq	NSWMSC WMA LAs
	WtE plant 1 to be implemented strategically at a location Covering Central & North Central province to ensure energy production from waste that were unable to be recycled or reused. GHG reduction In 2036 – 143 MT CO_2 – eq In 2040 – 144 MT CO_2 – eq	Ministry of Power &Energy, LAs, CEB NSWMSC SLLDC WMA LAs Private sector
	Promote circular economy in construction industry	Department of Buildings SLSEA SLAMERP SLAEA UNDP WMA
2041 2045	WtE plant 2 to be implemented strategically at location covering Northern, Easter and North Central Province thus, the transportation of waste to the facility to be optimized. GHG reduction In 2041 – 287 MT CO_2 – eq In 2050 – 271 MT CO_2 – eq Two WtE plants are implemented to replace the Coal plants thus ensuring the net GHG emission reduction in the content of the net gain from moving towards sustainable practices. Moreover, both the WtE plants have to be equipped with Carbon Stacks to further replace the Carbon released to the atmosphere.	Ministry of Power & Energy LAs CEB NSWMSC SLLDC WMA LAs Private sector
	Promoting zero-carbon innovations	NRC
2046- 2050	A Sanitary landfill have to introduced to strategically dispose the unavoidable waste generated and that cannot be used as a fuel to the WtE plants. The expected GHG reduction by the facility is 63 MT CO_2- eq . by 2050.	NSWMSC WMA LAs CEA Private sector

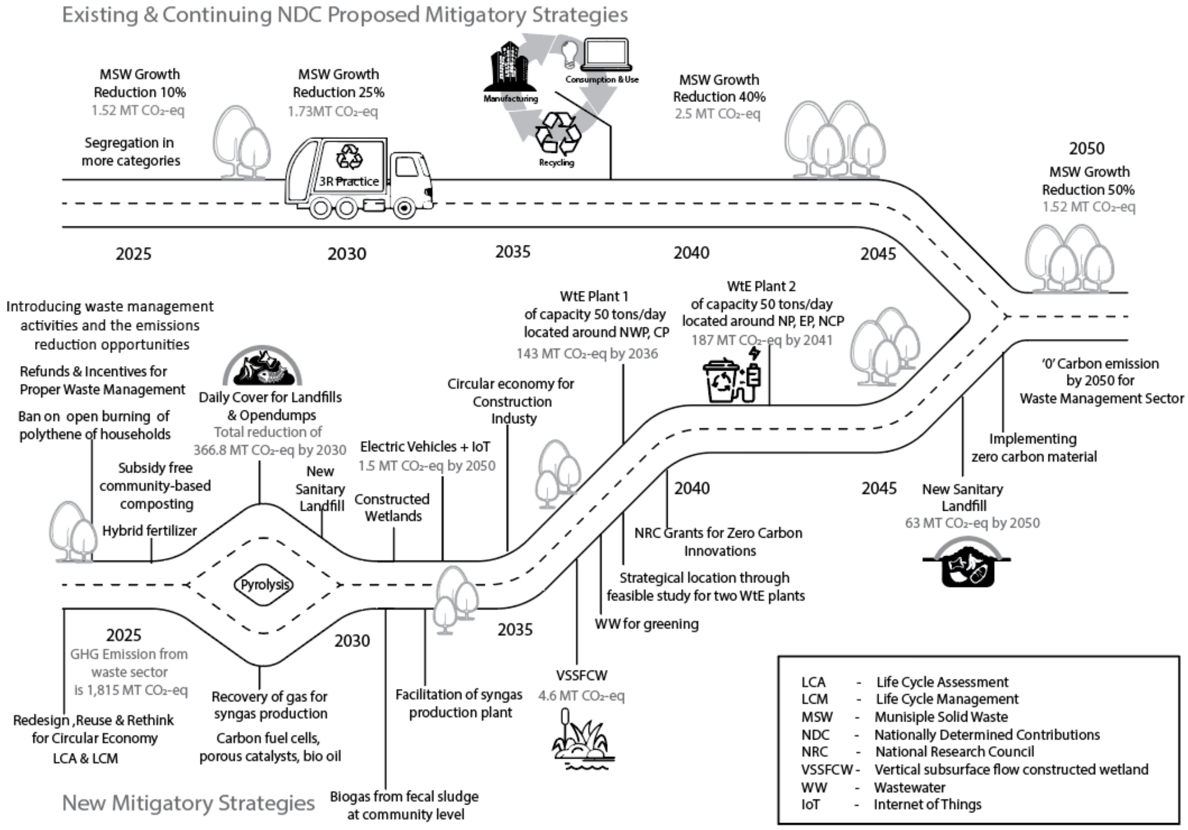


Figure 5.1 : Road Map for Waste Sector

5.1.5 <u>Agriculture Sector</u>

Table 5.5: Five-year Interval Plan in Agriculture Sector

Five-year plan for agriculture sector was developed to implement five main strategies namely, application of mitigatory measures for paddy lands, local and imported neat cattle, goats and sheep, managing soil to minimize direct and indirect N_2O emissions, restricting importation of Urea and carbon sequestration.

Timeline	Activity	Responsible parties
2025-2030	Strategy (i) Paddy land extent target: 147,750 ha (Yala and Maha) a. Removal of straws from paddy fields b. Manufacturing paper and different types of boards d. Production of bio fuel e. Packaging industry Strategy (ii) No. of heads (neat cattle/Goat/Sheep) target: 146,278 a. Feed quality improvement b. Night feeding and supply of water c. Animal comfort improvement (heat reduction, free roaming) Strategy (iii) N_2O reduction Giga tones 0.95 a. Manure management b. Soil tillage reduction Strategy (iv)	Strategy (i) National Paper Company Ltd,, Valaichchenai and Embilipitiya, Durra Building Systems (Pvt) Ltd Strategy (ii) Department of Animal Production and Health, National Livestock Development Board, Market Oriented Dairy Project Strategy (iii) Department of Agriculture Strategy (iv)

Timeline	Activity	Responsible parties
	Reduction of fertilizer: Urea 31,287 Mt a. Reduction of artificial fertilizer application Strategy (v) Lands under carbon Sequestration 2,155 ha	 Department of Agriculture Fertilizer Secretariate Fertilizer Cooperation CIC, Bower Strategy (v) Department of Agriculture Department of Agrarian Services
2031-2035	Strategy (i) Paddy land extent target: 197,000 ha (Yala and Maha) a. Export of paddy straw b. Manufacture paper c. Manufacture boards d. Production of bio fuel e. Packaging industry Strategy (ii) No. of heads (neat cattle/Goat/Sheep) target 195,037 a. Feed quality improvement b. Night feeding c. Supply of Drinking water d. Animal comfort improvement (Heat reduction, Free roaming) Strategy (iii) N_2O reduction 1.27 Giga Tones a. Manure management	Strategy (i) Durra Building Systems (Pvt) Ltd Governmental and non-governmental organizations Kankasanthurai and Ambilipitiya paper mills Strategy (ii) Department of Animal Production and Health National Livestock Development Board Market Oriented Dairy Project Strategy (iii) Department of Agriculture

Timeline	Activity	Responsible parties
	b. Soil tillage reduction Strategy (iv) Reduction of fertilizer: Urea 41,716 Mt a. reduction of artificial fertilizer application Strategy (v) Lands under carbon Sequestration 2,155 ha	Strategy (iv) Department of Agriculture Fertilizer Secretariate Fertilizer Cooperation CIC, Bower Strategy (v) Department of Agriculture Department of Agrarian Services
2036-2040	Strategy (i) Paddy land extent target: 246,250 ha (Yala and Maha) a. Export of paddy straw b. Manufacture paper c. Manufacture boards d. Production of bio fuel e. Packaging industry Strategy (ii) No. of heads (neat cattle/Goat/Sheep) target 243,796 a. Feed quality improvement b. Night feeding c. Supply of Drinking water d. Animal comfort improvement (Heat reduction, Free roaming) Strategy (iii) N_2O reduction 1.58 Giga Tones a. Manure management	Strategy (i) Durra Building Systems (Pvt) Ltd Governmental and non-governmental organizations Kankasanthurai and Ambilipitiya paper mills Strategy (ii) Department of Animal Production and Health National Livestock Development Board Market Oriented Dairy Project Strategy (iii) Department of Agriculture

Timeline	Activity	Responsible parties
	b. Soil tillage reduction Strategy (iv) Reduction of fertilizer: Urea 52,146 Mt a. Reduction of artificial fertilizer application Strategy (v) Lands under carbon Sequestration 2,155	 Strategy (iv) Department of Agriculture Fertilizer Secretariate Fertilizer Cooperation CIC, Bower Strategy (v) Department of Agriculture Department of Agrarian Services
2041-2045	Strategy (i) Paddy land extent target: 197,000 ha Yala and Maha) a. Export of paddy straw b. Manufacture paper c. Manufacture boards d. Production of bio fuel e. Packaging industry Strategy (ii) No. of heads (neat cattle/Goat/Sheep) target 195,037 a. Feed quality improvement b. Night feeding c. Supply of Drinking water d. Animal comfort improvement (Heat reduction, Free roaming) Strategy (iii) N_2O reduction 1.27 Giga Tones	Strategy (i) Durra Building Systems (Pvt) Ltd Governmental and non-governmental organizations Kankasanthurai and Ambilipitiya paper mills Strategy (ii) Department of Animal Production and Health National Livestock Development Board Market Oriented Dairy Project Strategy (iii) Department of Agriculture

Timeline	Activity	Responsible parties
	a. Manure management b. Soil tillage reduction Strategy (iv) Reduction of fertilizer: Urea 41,717 Mt a. Reduction of artificial fertilizer application Strategy (v) Lands under carbon Sequestration 2,155 ha	 Strategy (iv) Department of Agriculture Fertilizer Secretariate Fertilizer Cooperation CIC, Bower Strategy (v) Department of Agriculture Department of Agrarian Services
2046-2050	Strategy (i) Paddy land extent target: 98,500 ha (Yala and Maha) a. Export of paddy straw b. Manufacture paper c. Manufacture boards d. Production of bio fuel e. Packaging industry Strategy (ii) No. of heads (neat cattle/Goat/Sheep) target 97,519 a. Feed quality improvement b. Night feeding c. Supply of Drinking water d. Animal comfort improvement (Heat reduction, Free roaming) Strategy (iii) N_2O reduction 0.63 Giga Tonnes a. Manure management	Strategy (i) Durra Building Systems (Pvt) Ltd Governmental and non-governmental organizations Kankasanthurai and Embilipitiya paper mills Strategy (ii) Department of Animal Production and Health National Livestock Development Board Market Oriented Dairy Project Strategy (iii) Department of Agriculture

Timeline	Activity	Responsible parties
	b. Soil tillage reduction Strategy (iv) Reduction of fertilizer: Urea 20,858 Mt a. Reduction of artificial fertilizer application Strategy (v) Lands under carbon Sequestration 2,155	 Strategy (iv) Department of Agriculture Fertilizer Secretariate Fertilizer Cooperation CIC, Bower Strategy (v) Department of Agriculture Department of Agrarian Services

Table 5.6 : Five year plan - Totals

Five year period	Paddy lands mitigated Hectares	Livestock (Number of heads mitigated)	Direct and Indirect N2O MT mitigated	Urea import restricted MT
2025/2030	147,750	14,6278	0.95	31,287
2031/2035	197,000	19,5037	1.27	41,717
2036/2040	246,250	24,3796	1.58	52,147
2041/2045	197,000	19,5037	1.27	41,717
2046/2050	98,500	97,519	0.63	20,858

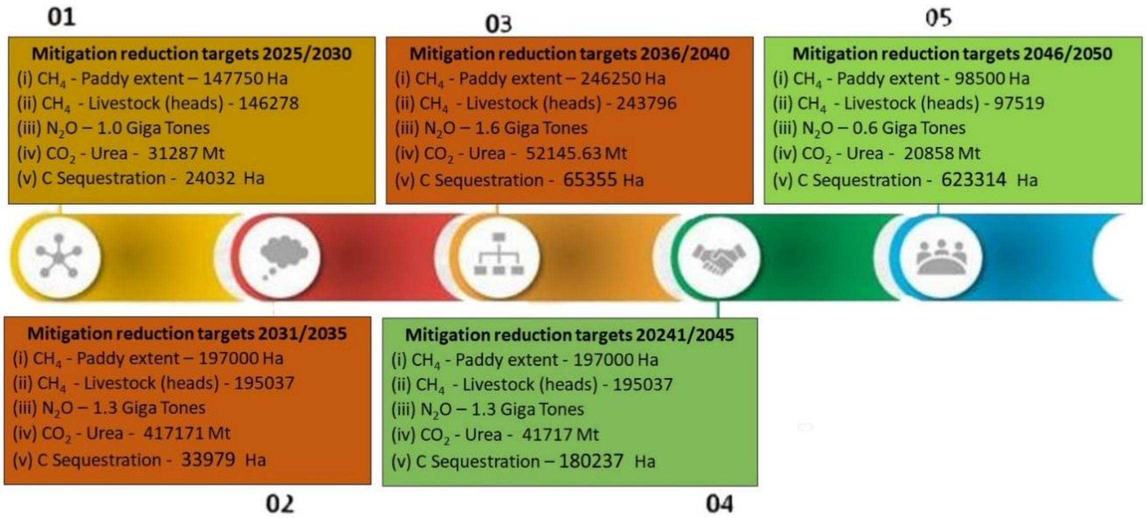


Figure 5.2 : Carbon Net Zero Road Map – Agriculture Sector

5.1.6 Forestry Sector

Table 5.7: Five-year Interval Plan in Forestry Sector

Timeline	Activity	Responsible parties
2025-2030	Deforestation rate would not exceed 5000 ha per year	Forest Department, MASL, RPC, Divisional Administration
	Afforest 1805 (from the already committed area in the NDCs) and 9212 ha (from the 200,000 ha which was retrieved from the areas which were categories under 'Other State Forests' annually	Forest Department, MASL, RPC
	Take measures to reduce the annual loss of homegardens which is now at 0.3% per year	Forest Department, Department of Agriculture, Department of Minor Export Crops, Provincial and District/Divisional Administration
	Planting 80937 ha of coconut plantations per year	Coconut Cultivation Board, Coconut Research Institute, RPCs, Private sector
	Stop the deforestation of mangroves which is 1% per year and plant 100 ha annually	Forest Department, Coast Conservation and Coastal Resource Management Department, IUCN, private sector
	Maintain 40 trees/ha of shade trees in tea plantations and increase the annual tea extent by 15000 ha	Tea Cultivation Board, RPC, SLSPC
	Addition of 1500000 trees in urban and suburban areas per year	UDA, private sector, Forest Department, MASL
2031-2035	Rate of deforestation will be reduced from 5000 ha to 2000 ha	Forest Department, MASL, RPC, Divisional Administration
	Afforest 1805 (from the already committed area in the NDCs) and 9212 ha (from the 200,000 ha which	Forest Department, MASL, RPC

Timeline	Activity	Responsible parties
	was retrieved from the areas which were categories under 'Other State Forests' annually	
	Take measures to reduce the annual loss of homegardens which is now at 0.3% per year	Forest Department, Department of Agriculture, Department of Minor Export Crops, Provincial and District/Divisional Administration
	Planting 80937 ha of coconut plantations per year	Coconut Cultivation Board, Coconut Research Institute, RPCs, Private sector
	Stop the deforestation of mangroves which is 1% per year and plant 100 ha annually	Forest Department, Coast Conservation and Coastal Resource Management Department, IUCN, private sector
	Maintain 40 trees/ha of shade trees in tea plantations and increase the annual tea extent by 15000 ha	Tea Cultivation Board, RPC, SLSPC
	Addition of 1500000 trees in urban and suburban areas per year	UDA, private sector, Forest Department, MASL
2036-2040	Rate of deforestation will be reduced from 2000 ha to 500 ha	Forest Department, MASL, RPC, Divisional Administration
	Afforest 1805 (from the already committed area in the NDCs) and 9212 ha (from the 200,000 ha which was retrieved from the areas which were categories under 'Other State Forests' annually	Forest Department, MASL, RPC
	Take measures to reduce the annual loss of homegardens which is now at 0.3% per year	Forest Department, Department of Agriculture, Department of Minor Export Crops, Provincial and District/Divisional Administration

Timeline	Activity	Responsible parties
	Planting 80937 ha of coconut plantations per year	Coconut Cultivation Board, Coconut Research Institute, RPCs, Private sector
	Stop the deforestation of mangroves which is 1% per year and plant 100 ha annually	Forest Department, Coast Conservation and Coastal Resource Management Department, IUCN, private sector
	Maintain 40 trees/ha of shade trees in tea plantations and increase the annual tea extent by 15000 ha	Tea Cultivation Board, RPC, SLSPC
	Addition of 1500000 trees in urban and suburban areas per year	UDA, private sector, Forest Department, MASL
2041-2045	Rate of deforestation will be reduced from 500 ha to 100 ha	Forest Department, MASL, RPC, Divisional Administration
	Afforest 1805 (from the already committed area in the NDCs) and 9212 ha (from the 200,000 ha which was retrieved from the areas which were categories under 'Other State Forests' annually	Forest Department, MASL, RPC
	Take measures to reduce the annual loss of homegardens which is now at 0.3% per year	Forest Department, Department of Agriculture, Department of Minor Export Crops, Provincial and District/Divisional Administration
	Planting 80937 ha of coconut plantations per year	Coconut Cultivation Board, Coconut Research Institute, RPCs, Private sector
	Stop the deforestation of mangroves which is 1% per year and plant 100 ha annually	Forest Department, Coast Conservation and Coastal Resource Management Department, IUCN, private sector
	Maintain 40 trees/ha of shade trees in tea plantations and	Tea Cultivation Board, RPC, SLSPC

Timeline	Activity	Responsible parties
	increase the annual tea extent by 15000 ha	
	Addition of 1500000 trees in urban and suburban areas per year	UDA, private sector, Forest Department, MASL
2046-2050	Rate of deforestation will be reduced from 100 ha to 0 ha	Forest Department, MASL, RPC, Divisional Administration
	Afforest 1805 (from the already committed area in the NDCs) and 9212 ha (from the 200,000 ha which was retrieved from the areas which were categories under 'Other State Forests' annually	Forest Department, MASL, RPC
	Take measures to reduce the annual loss of homegardens which is now at 0.3% per year	Forest Department, Department of Agriculture, Department of Minor Export Crops, Provincial and District/Divisional Administration
	Planting 80937 ha of coconut plantations per year	Coconut Cultivation Board, Coconut Research Institute, RPCs, Private sector
	Stop the deforestation of mangroves which is 1% per year and plant 100 ha annually	Forest Department, Coast Conservation and Coastal Resource Management Department, IUCN, private sector
	Maintain 40 trees/ha of shade trees in tea plantations and increase the annual tea extent by 15000 ha	Tea Cultivation Board, RPC, SLSPC
	Addition of 1500000 trees in urban and suburban areas per year	UDA, private sector, Forest Department, MASL

5.2 Economic Analysis of Achieving Net Zero Status in Sri Lanka

In order to achieve Net Zero Status in Sri Lanka, a variety of options have been proposed for each sector. Emission reduction (ER) options and sequestration enhancement (SE) options have been proposed under the proposed strategy towards achieving net zero status. It is important to analyze the proposed options to find out their economic viability. Economic viability for each option was assessed based on projected costs for future (up to 2050) and carbon emission savings. World Bank (2017) has proposed Guidelines on value of carbon. Guidance note on shadow price of carbon in economic analysis published by World Bank suggests that shadow price of carbon in US$ per 1 metric ton of CO2 equivalent to be USD 42 (lower estimate) and USD 84 (upper estimate) for the year 2022. Net present value was calculated for each option using a discount rate of 10%.

The following table provides summary of the calculation and provides Net Present Values (NPV) for the energy and transport sectors.

Table 1: Investments required for the Energy sector

Period	Total investment cost (LKR million)
2025 - 2029	2,131,408
2030 - 2034	3,003,414
2035 - 2039	4,112,132
2040 - 2044	5,635,990
2045 - 2050	5,748,165
Present value @ 10%	5,796,452

Table 2: Investments required for the Transport sector

Period	Total investment cost (LKR million)
2030 - 2034	16,334,558
2035 - 2039	20,914,278
2040 - 2044	26,786,734
2045 - 2050	36,145,677
Present value @ 10%	37,052,201

Table 5.8: Net present values of proposed mitigation actions for Energy and Transport sectors

Sector and Mitigation options	Net Present Value (LKR) @ 10% discount rate	
	Value of avoided Carbon (lower estimate)	Value of avoided Carbon (upper estimate
Energy sector		
Proposed Mitigation Scenario 02- Energy Sector decarbonization	-5,105,443,005,555	-4,412,922,592,074
Transport sector Emission reduction options		
1. Railway Electrification	-16,443,331,238	-15,176,037,288
2. Interprovincial Bus Electrification	-97,992,697,344	-70,897,175,975
3. Provincial Bus Electrification	-141,288,818,341	-128,430,869,073
4. Private and Freight Vehicles Electrification	-36,292,770,688,495	-35,828,728,616,907
All four options	-36,548,495,535,418	-36,043,232,699,243

The higher operational and capital costs associated with energy options have resulted in large negative net present values. The proposed renewable energy options however, may generate other local benefits and avoided thermal generations may also lead to significant pollution damage cost savings for the country especially health benefits. There may be additional environmental and social burdens due to some of the proposed energy options such as nuclear power.

Similarly, higher operational and capital costs associated with transport options have resulted in large negative net present values. Individual analysis of all transport options also show negative net present values. There are however, several benefits of transport sector options that have not been estimated. For example, the above calculation has not taken into account the time savings of the commuters, vehicle emission savings etc. associated with the improved rail and other transport modes with electrification. In addition there will be health benefits due to the reduced emission of PM2.5 and other air pollutants from avoided use of fossil fuels in transport.

The following table provides summary of the calculation and Net Present Values (NPV) for the waste sector.

Table 3: Investments required for the Waste sector

Period	Total investment cost (LKR million)
2026 - 2030	15
2031 - 2035	32
2036 - 2040	71,221
2041 - 2045	906
2046 - 2050	38,434
Present value @ 10%	22,722

Table 5.9: Net present values of proposed mitigation actions for waste sector

	Net Present Value (LKR) @ 10% discount rate	
	Value of avoided Carbon (lower estimate)	**Value of avoided Carbon (lower estimate)**
Emission reduction (ER) options and sequestration enhancement (SE) options		
ER option 1: Syngas recovery from open dump	-5,052,744.20	53,115,328.99
ER option 2: Electric vehicle for waste collection	-1,959,271,804.33	-1,940,537,516.89
ER option 3: Waste to energy plants	-24,739,041,603.49	13,887,404,121.78
ER option 4: Sanitary landfill	-18,721,691,991.70	-3,540,883,638.19
SE option 1: Daily Cover for Open dump	12,523,805,993.20	25,079,884,074.14
SE option 2: Vertical Subsurface flow constructed wetland (VSSFCW)	17,526,843,002.79	35,118,949,434.14
All 6 options combined	4,346,928,810.96	25,805,688,533.22

Among the proposed options of waste sector Daily Cover for Open dump and Vertical Subsurface flow constructed wetland (VSSFCW) have resulted in positive net present values. When all options for waste sector are considered together, it has resulted in positive net present values.

The following table provides Net Present Values for the forestry sector.

Table 4: Investments required for the Forestry sector

Period	Total investment cost (LKR million)
2025 - 2029	261,433
2030 - 2034	303,178
2035 - 2039	400,335
2040 - 2044	539,913
2045 - 2050	847,261
Present value @ 10%	641,840

Table 5.10: Net present values of proposed mitigation actions for Forestry sector

Sector and Mitigation options	Net Present Value (LKR) @ 10% discount rate	
	Value of avoided Carbon (lower estimate)	Value of avoided Carbon (upper estimate)
Forests in natural forests and plantations	$1,481,668,327,940.23	3,129,478,180,480
Trees Outside Forests		
Homegardens	816,056,745,585	1,656,563,163,232
Coconut plantations	469,289,070,006	1,637,038,422,127
Tea plantations with shade trees	70,930,596,918	141,838,967,699
Mixed trees with other perennials	64,883,821,812	129,681,864,833
Urban green cover and areas with avenue plants	-56,994,596,077	43,041,161,765
Blue Carbon Ecosystems		
Mangroves	72,657,022,054.15	164,789,655,745
Total for all options	2,832,663,961,588.63	6,302,663,521,836

Among the proposed actions of forestry sector, all actions have resulted in positive net present values except for urban green cover and areas with avenue plants under lower estimate of value of avoided carbon. When all actions for forestry sector are considered together, it has resulted in positive net present value of 2832 LKR billion under lower value of carbon and 6302 LKR billion under upper value of carbon. This analysis however has not taken into account variety of other benefits resulting from increasing forest cover including benefits due to variety of ecosystem services. There are variety of direct and indirect economic benefits associated with homegadens and mangrove forests. Benefits of increased extents of plantations will generate additional direct income.

The following table provides Net Present Values (NPV) for the Agriculture sector.

Table 5: Investments required for the Agriculture sector

Period	Total investment cost (LKR million)
2023 - 2027	69,776
2028 - 2032	131,794
2033 - 2037	186,294
2038 - 2042	233,745
2043 - 2047	274,447
2048 - 2050	181,475
Present value @ 10%	252,647

Table 5.11: Net present values of proposed mitigation actions for agriculture sector

Mitigation actions	Net Present Value (LKR) @ 10% discount rate	
	Value of avoided Carbon (lower estimate)	Value of avoided Carbon (upper estimate)
Emission reduction treatment for neat cattle (both imported and local)	-198,931,253,860.50	-198,882,959,958.46
All actions in agriculture sector including actions to mitigate emissions related to Rice Cultivation, Urea Applications and Direct/Indirect N2O	-198,738,491,541.80	-198,497,416,260.95

The lower emission reductions and higher costs associated with agricultural actions have resulted in large negative net present values. The above analysis assumed actions to mitigate emissions related to Rice Cultivation, Urea Applications and Direct/Indirect N2O as costless.

Summary

The following table provides summary for all sectors, the present values of all costs and benefits for each sector.

Table 5.12: 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 5.13: 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 positive net present value of 1000 LKR billion indicating the viability of the remaining sectors under 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 in order to finance the proposed mitigation measures from international sources.

Table 6 provides details related to investments required for all sectors.

Table 6: 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

Policy recommendations

Net zero pathway requires vast amounts of investment, innovation, skilful policy design and implementation, technology deployment, infrastructure building, international co-operation and efforts across many other areas. Challenge of transforming our energy systems is also a huge opportunity for our economies, with the potential to create millions of new jobs and boost economic growth. Another guiding principle of the Roadmap is that clean energy transitions must be fair and inclusive, leaving nobody behind. Government R&D spending needs to be increased and reprioritised. Critical areas such as electrification, hydrogen, bioenergy and carbon capture, utilization and storage (CCUS) today receive very little or no public R&D funding. Support is also needed to accelerate the roll-out of demonstration projects, to leverage private investment in R&D, and to boost overall deployment levels to help reduce costs.

Some of the changes brought by the clean energy transformation may be challenging to implement, so decisions must be transparent, just and cost-effective. Governments need to ensure that clean energy transitions are people-centered and inclusive. Household energy expenditure as a share of disposable income – including purchases of efficient appliances and fuel bills – rises modestly in developing economies as more people gain access to energy and demand for modern energy services increases rapidly. Ensuring the affordability of energy for households demands close attention: policy tools that can direct support to the poorest include tax credits, loans and targeted subsidies.

Energy transitions have to take account of the social and economic impacts on individuals and communities, and treat people as active participants. The transition to net zero brings substantial new opportunities for employment. Spending on more efficient appliances, electric and fuel cell vehicles, and building retrofits and energy-efficient construction would require a additional workers. But these opportunities are often in different locations, skill sets and sectors than the jobs that will be lost as fossil fuels decline. This requires careful policy attention to address the employment losses. It will be vital to minimise hardships associated with these disruptions, such as by retraining workers, locating new clean energy facilities in heavily affected areas wherever possible, and providing regional aid. Improvements in air quality provide major health benefits also.

For many developing countries, the pathway to net zero without international assistance is not clear. Technical and financial support is needed to ensure deployment of key technologies and infrastructure. Without greater international co-operation, global CO_2 emissions will not fall to net zero by 2050.

By 2025, all countries should have a long- term CO_2 emissions reduction policy framework in place to provide certainty that the next wave of investment in capacity additions will feature near-zero emissions technologies. Successful strategies are likely to require initial measures such as carbon contracts for difference, public procurement and incentives to encourage private sector procurement. As new technologies are deployed and costs decline, there is likely to be a strong case by about 2030 for replacing these initial measures with others such as CO_2 taxes, emissions trading systems and emissions performance standards. Financing support for near-zero emissions capacity additions may also have an important role to play through measures such as low interest and concessional loans and blended finance, as well as through contributions by advanced economies to funds that support projects in emerging market and developing economies.

Strategies should also include measures to reduce industrial emissions through material efficiency, for example by revising design regulations, adopting incentives to promote longer product and building lifetimes, and improving systems for collecting and sorting materials for recycling. There is a strong case for an international agreement on the transition to near-zero emissions for globally traded products by the mid-2020s so as to establish a level playing field. Alternatively, countries may need to resort to measures to shield domestic near-zero emissions production from competition from products that create emissions. Any such policy would need to be designed to respect the regulatory frameworks governing international trade, such as those of the World Trade Organization.

Governments should not overlook the need for measures to spur deployment of already available near-zero emissions technologies in light manufacturing industries. Adopting a carbon price and then sufficiently increasing the price over time – through carbon taxes or emissions trading systems for larger manufacturers – may be the simplest way to achieve that objective. Other regulatory measures such as tradable low-carbon fuel and emissions standards could yield the same outcome, but may involve greater administrative complexity. Technology mandates are likely to be needed to achieve the energy efficiency savings, such as minimum energy performance standards for new motors and boilers. Tailored programmes and incentives for small and medium enterprises could also play a helpful role.

Large proportion of emissions could be saved by behavioral changes which could be directly influenced or mandated by government policy . They include mitigation measures such as phasing out polluting cars from large cities and reducing speed limits on motorways.

To implement carbon pricing, it would benefit from developing the monitoring, reporting and verification structures necessary to implement a robust and comprehensive cap-and-trade-style market. A combination of investments in monitoring systems, data collection networks, and policies to incentivize data accuracy and disclosure could help speed up the potential for carbon markets to play a substantive role in incentivizing emissions reductions

SECTION 6: RECOMMENDATIONS

- It is acknowledged that the proposed action plan does not include any road map for financing the proposed strategic actions. The Central Bank of Sri Lanka, have recommended that in order to facilitate and ensure the timely implementation of the action plans, the key focus should be on alternative financing options than on budgetary allocations. It is recommended that green financing options available locally and internationally should be investigated and approached for funding the investments needed to achieve the desired outcomes. It is imperative that a Road map for financing the proposed actions is also prepared in order to see the successful implementation of the Plan.
- The Central Bank of Sri Lanka has already prepared a 'Green Finance Taxonomy' for the Sri Lanka's banking sector, with the aim of promoting lending through the domestic financial system to green projects. Therefore, seeking concessional or priority-based funding for zero carbon projects from the banking sector could be considered as a financing option going forward.
- Implementation of the actions proposed to achieve Carbon Net Zero involves the participation of state as well as private sector institutions, as well as individual citizens, and it is important that a high level of participation is forthcoming from all stakeholders
- To ensure sustainable growth, investing in research and development becomes 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 the carbon emissions, which will further attract innovation and drive industry expansion.
- While much effort has been taken to include the opinions of the decision-making officials in the government sector in the development of the strategic plan, through stakeholder consultations, this being a long-term plan, needs to be regularly updated with data available in the future. The government should encourage an open dialogue with all stakeholders and monitor the achievement of the Key Performance Indicators on a regular basis, at least biennially, and review the Strategic Plan and Road Map accordingly. As pointed out by the Ceylon Chamber of Commerce (CCC) in their comments on the Draft Final Report at the validation workshop, a consultative process is essential for ensuring that the plan reflects the needs and interests of the business sector, which is a key driver of growth and innovation in our country. In this regard, they urge the government to establish a more regular and transparent dialogue with the trade Chambers and their members, so that future national plans can follow a due process that incorporates diverse perspectives and feedback from relevant stakeholders.
- As emphasised by the CCC in their comments at the validation workshop of the Strategic Plan and Road Map, appropriate mechanisms that are transparent and effective should be established by the government for collection, analysis and acting on stakeholder feedback, and these should be communicated to the public.

- In the monitoring and regulation of emission, CCC has recommended the use of platforms such as “Carbon Mapper” or citizen engagement apps like “Man Kiwwa” to proactively identify sources of emissions and take prompt action to curb the emissions. It is suggested to launch a Spatial Finance Initiative in Sri Lanka with the support of the Sri Lanka Banks’ Association’s Sustainable Banking Initiative and Ceylon Chamber of Commerce’s ESG Financing Subgroup with the GoSL providing access to the spatial data in an easy to use form to the financial sector to engage constructively with private sector clients to manage their risks.
- As stated in the National Climate Change Policy, it is imperative that the Climate Change is mainstreamed and integrated in the National Development Process. The strategies and actions proposed in the Strategic Plan and Road Map will need to be internalized into the development plans of the relevant institutions, in order to achieve the vision of “A CARBON NEUTRAL PROSPEROUS SRI LANKA”. To ensure that this Roadmap is integrated to the strategy of private sector, the CCC is recommending that it is important for Governance and Disclosures of Private Sector to be aligned, and as a first step, GoSL (Climate Change Secretariat) could work with Ceylon Chamber of Commerce to support private sector adoption of Climate and Nature Related Financial Disclosures (TCFD and TNFD), starting with corporates with revenue over LKR 15bn, encouraging them to take a perspective not only of their own operations but of their value chain/business ecosystem and just transition.

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
ENERGY SECTOR										
ENERGY SECTOR (Option 1- With Nuclear Program)	Promotion of renewable energy.	Adding following Power Plants for Power Generation	Pumped Storage 700 MW Mini Hydro - 135 MW Biomass-120 MW Wind - 1390 MW Solar - 3015 MW Battery Energy Storagett 725 MW/2900 MWh	Pumped Storage 700 MW Mini Hydro - 50 MW Biomass - 90 MW Wind - 800 MW Solar - 2420 MW Battery Energy Storage 675 MW/ 2700 MWh	Mini Hydro - 40 MW Biomass - 50 MW Wind - 750 MW Solar - 2650 MW Battery Energy Storage 515 MW/ 2060 MWh	Biomass 120 MW Wind 950 MW Solar 2830 MW Battery Energy Storage 625 MW/ 2500 MWh	Biomass - 150 MW Wind - 1300 MW Solar - 3150 MW Battery Energy Storage 625 MW/ 2500 MWh	MoPE/CEB MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB/SLSEA	-Proper renewable energy resource assessment and firm RE development plan. -An agency for facilitating the financing mechanism for green energy projects. - Upgraded transmission network to integrate more REs. -Energy sector market structure to facilitate RE integration. -Expedite land acquisition mechanism for RE projects and transmission network expansions. -Sufficient amount of materials/equipment for RE projects (major components are imported dependent). -Sufficient human resource	-Unavailability of firm RE resource development plan. -Lack of finances and sovereign /treasury guarantee to the energy sector finances. -Policy and statutory bottlenecks for speedy RE additions. -Unavailability of sufficient financing for transmission network upgrade. -Not enough local manufacturing of materials/equipment for RE projects No sufficient human resource/ expert on this area
	GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)		No additional reduction as it is in line with the base case scenario	78	131	1087	1899			
	KPI	Pump hydro added to the system	700 MW	700 MW						

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
		Number of MW of Mini-hydro added to the system.	135 MW	50 MW	40 MW					
		Number of MW of biomass added to the system.	120 MW	90 MW	50 MW	120 MW	150 MW			
		Number of MW of wind PV added to the system	1390 MW	800 MW	750 MW	950 MW	1300 MW			
		Number of MW of solar PV added to the system	3015 MW	2420 MW	2650 MW	2830 MW	3150 MW			
		Capacity of battery storage added to the system.	725 MW/2900 MWh	675 MW/ 2700 MWh	515 MW/ 2060 MWh	625 MW/ 2500 MWh	625 MW/ 2500 MWh			
	Development of Nuclear energy resources to the optimum level with sufficient environmental safeguards, by encouraging market demand for such resources	Adding Nuclear Power Plants for power generation Note: Government should take a firm policy decision on nuclear program. If the nuclear program is not continue, option 2 shall be considered.		Nuclear - 600 MW	Nuclear - 1000 MW				-An agency for facilitating the financing mechanism for green energy projects. -Upgraded transmission network to integrate more REs. -A mechanism to enhance the social acceptance of nuclear energy. -Sufficient human resource	-Policy and statutory bottlenecks for speedy integration of nuclear power plant. -Unavailability of sufficient financing for the project. -An agency to facilitate nuclear energy power plant development and to enhance the social acceptance -No sufficient human resource/ expert on this area
	GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)			1280	3229	5842	3397			
	KPI	Number of MW of nuclear power added to the system		600 MW	1000 MW					

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	**2031 – 2035**	**2036 - 2040**	**2041 - 2045**	**2046 - 2050**			
ENERGY SECTOR (Option 2- Without Nuclear Program)	Promotion of renewable energy.	Adding following Power Plants for Power Generation	Pumped Storage 700 MW Mini Hydro - 135 MW Biomass-120 MW Wind - 1390 MW Solar - 3015 MW Battery Energy Storage 725 MW/2900 MWh	Pumped Storage 700 MW Mini Hydro - 50 MW Biomass - 90 MW Wind - 1200 MW Solar - 3350 MW Battery Energy Storage 850 MW/ 3400 MWh	Mini Hydro - 40 MW Biomass - 50 MW Wind - 2050 MW Solar - 4700 MW Battery Energy Storage 1175 MW/ 4700 MWh	Biomass 120 MW Wind 2050 MW Solar 4550 MW Battery Energy Storage 1140 MW/ 4560 MWh	Biomass - 150 MW Wind - 2800 MW Solar - 3300 MW Battery Energy Storage 825 MW/ 3300 MWh	MoPE/CEB MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB/SLSEA MoPE/CEB/SLSEA	-Proper renewable energy resource assessment and firm RE development plan. -An agency for facilitating the financing mechanism for green energy projects. - Upgraded transmission network to integrate more REs. -Energy sector market structure to facilitate RE integration. -Expedite land acquisition mechanism for RE projects and transmission network expansions. -Sufficient amount of materials/equipment for RE projects (major components are imported dependent). -Sufficient human resource	-Unavailability of firm RE resource development plan. -Lack of finances and sovereign /treasury guarantee to the energy sector finances. -Policy and statutory bottlenecks for speedy RE additions. -Unavailability of sufficient financing for transmission network upgrade. -Not enough local manufacturing of materials/equipment for RE projects No sufficient human resource/ expert on this area
	GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)		No additional reduction as it is in line with the base case scenario	1,358	3,360	6,929	5,296			
	KPI	Pump hydro added to the system	700 MW	700 MW						
		Number of MW of Mini-hydro added to the system.	135 MW	50 MW	40 MW					

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
		Number of MW of biomass added to the system.	120 MW	90 MW	50 MW	120 MW	150 MW			
		Number of MW of wind PV added to the system	1390 MW	1200 MW	2050 MW	2050 MW	2800 MW			
		Number of MW of solar PV added to the system	3015 MW	3350 MW	4700 MW	4550 MW	3300 MW			
		Capacity of battery storage added to the system.	725 MW/2900 MWh	850 MW/ 3400 MWh	1175 MW/ 4700 MWh	1140 MW/ 4560 MWh	825 MW/ 3300 MWh			
	Promote Regional Power Grid Connectivity and Cross-Border Electricity Trade	Adding Cross Border Interconnection		Adding Cross Border Interconnection - 500 MW			Adding Cross Border Interconnection - 500 MW	MoPE/CEB	-Energy sector market structure to facilitate cross border energy trading. -Expedite land acquisition mechanism for the transmission network expansions. -Sufficient human resource	-Policy and statutory bottlenecks for speedy integration of nuclear power plant. -Unavailability of sufficient financing for the project. -No proper Energy sector market structure to facilitate cross border energy trading. -No sufficient human resource/ expert on this area
	GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)			512	1662	1849	2503			
	KPI	Total Capacity additions of cross border added to the system.		500 MW			500 MW			

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	**2031 – 2035**	**2036 - 2040**	**2041 - 2045**	**2046 - 2050**			
	Gradual decommissioning of the existing thermal power plants which depends on imported fossil fuel and enhance self-reliance.	Retirement of following Thermal Plants for Power Generation	Diesel 437.4 MW	Diesel - 491.7 MW Diesel/Natural Gas 398 MW		Coal 900 MW	Diesel/Natural Gas 895 MW		-A proper plan for Decomposition, reuse and recycling the identified plants. -Sufficient human resource -Sufficient machinery and equipment	-Policy and statutory bottlenecks for decommissioning thermal power plants -No sufficient human resource/ expert on this area -No Sufficient machinery and equipment
	GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)		No additional reduction as it is inline with the base case scenario	1081		No additional reduction as it is in line with the base case scenario	2614			
	KPI	Number of MW of thermal plant retirements	Diesel 437.4 MW	Diesel - 491.7 MW Diesel/Natural Gas 398 MW		Coal 900 MW	Diesel/Natural Gas 895 MW			
	Energy Transition by Enabling the Continued use of Flexible and Secure Thermal Energy while Reducing Negative Impact to the Environment	Introduction of Green Hydrogen Introduction of Carbon Capturing and Storage		Introduction of Green Hydrogen				MoPE/SEA/PRDS MoPE/SEA/PRDS	-Proper feasibility study	-No Proper feasibility study

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	**2031 – 2035**	**2036 - 2040**	**2041 - 2045**	**2046 - 2050**			
	GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)					5493	5494			
	KPI	Number of MW of Hydrogen electrolyzes commissioned.								
		Hydrogen production in million metric tons from renewable electricity								
	Increase the share of biomass as a fuel used for cooking by introducing improved biomass conversion devices such as cook stoves and enhancing the commercial supply of biomass.	Increasing the share of biomass	Increasing the share of biomass	Increasing the share of biomass	Increasing the share of biomass					
	GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)		1377	2833	3833					
	KPI	Share biomass for cooking at the end of time period								

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
	Total GHG Emission Reduction by the end of the 5 years of period (1000 tonnes CO2e) Energy Sector		**1377**	**5784**	**8855**	**14271**	**15907**			
TRANSPORT SECTOR										
Transport Sector	Avoiding motorized transportation	**Improve the pedestrian infrastructure on collector type roads in the country**	Pedestrian infrastructure improved in 10,000 km of roads					Urban Development Authority, Road Development Authority, Provincial Road Development Authorities	Feasibility study to prioritize roads for ped improvement	Urban Development Authority, Road Development Authority, Provincial Road Development Authorities
GHG Emission Reduction (1000 tonnes CO2e)			119.90	121.71	123.55	125.42	127.31			
KPI	**No of km of road improved with walking tracks**		10000							
	Avoiding motorized transportation	**Construct cycling infrastructure island wide**	Cycling infrastructure improved along 10,000 km of roads					Urban Development Authority, Road Development Authority, Provincial Road Development Authorities, Ministry of Local Government	Feasibility study to prioritize roads for ped improvement Funding Design standards and guidelines	Technical capacity to get funding from alternative sources – green financing etc.
GHG Emission Reduction (1000 tonnes CO2e)			299.74	304.27	308.87	313.54	318.28			
KPI	**No of km of road improved with improved Cycling infrastructure**		10000							
	Avoiding need for transportation	**Promoting remote working**	100% implementation at the start of 2025					Ministry of Labour, Ministry of Finance, Ministry of Public Administration	Identify the action plan to implement this considering the requirements of each organization	Ministry of Labour, Ministry of Finance, Ministry of Public Administration
GHG Emission Reduction (1000 tonnes CO2e)			688.24	698.64	709.20	719.92	730.80			
KPI	**Survey on the No. of gov/ private institutions willing to implement remote working**		100% of the targeted number of institutions						Identify the action plan to implement this considering the	Policy level decision in coordination with all the ministries

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
			implementing the program						requirements of each organization Identify schemes to incentivize this program	Issue necessary gazette
		E-Commerce and E- Learning	Increase the e-commerce and e-learning activities to a pre-defined target level					Ministry of Trade & commerce, Ministry of Education, ICTA		
			412.94	419.18	425.52	431.95	438.48			
KPI	Market survey on the online transactions online & student e-learning usage & estimate the required increase in volume to achieve the trip reduction target		Achieve the increase in e-commerce/e-learning activities to reach the est trip reduction							
	Promoting public transportation	**Modernizing the bus fleet**	500 buses	1000 buses	2500 buses	5000 buses		Ministry of Transport & Highways	Funding Technical study to identify routes, level of modernization etc.	Technical capacity to get funding from alternative sources – green financing etc.
GHG Emission Reduction (1000 tonnes CO2e)			123.87	185.80	309.67	619.34	619.34			
KPI	**No. of Modernized busses**		500	1000	2500	5000				
	Pricing to reflect environmental cost of fossil fuels	**Implement a price formula for petrol and diesel to reflect global petroleum prices and exchange rates**	Implement from 2023 onwards					Ministry of Finance, Ministry of Power and Energy	Develop a comprehensive fuel price formula	Policy level decision at Ministry of Finance
GHG Emission Reduction (1000 tonnes CO2e			556.37	617.40	694.19	792.40	920.30			
KPI	**Price Formula in Effect**		Fuel Price Formula being gazetted							

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	**2031 – 2035**	**2036 - 2040**	**2041 - 2045**	**2046 - 2050**			
	Promoting public transportation	**Transport Demand Management Strategies in Key Cities**				Full implementation		Local government agencies, Urban Development Authority	Technical study to identify the most effective TDM	Ensure necessary legislative, land use, and municipality level changes are enacted
GHG Emission Reduction (1000 tonnes CO2e			405.02	411.14	417.35	423.66	430.06			
KPI	**No. of cities with transportation demand management (TDM) strategies**		Identify the TDM strategies for each city	All cities to implement the TDM strategies	Identify additional TDM strategies for each city	All cities to implement the TDM strategies				
	Promoting public transportation	**Implementation of LRT network in Colombo**	Completion of Malabe-Fort line					Ministry of Transport		Funding and identification of implementation agency
GHG Emission Reduction (1000 tonnes CO2e			50.00	53.00	53.00	100.00	100.00			
KPI	**Completion of LRT Network**		Completion of the LRT project							
	E-Mobility	**Railway Electrification**		Coastal line- Kaluthara	Puttalam line- Ragama	Main line – Polgahawela	Northern line – Polgahawela	Ministry of Transport		
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)			1.39	6.19	6.82	22.76	22.76			
KPI	**Completion of Railway Electrification**			Coastal line- Kaluthara	Puttalam line- Ragama	Main line – Polgahawela	Northern line – Polgahawela			
	E-Mobility	**Interprovincial Bus Electrification**	10% of the Interprovincial buses electrified	20% of the Interprovincial buses electrified	50% of the Interprovincial buses electrified	75 % of the Interprovincial buses electrified	100% of the Interprovincial buses electrified	Ministry of Finance, Ministry of Transport, National Transport Commission		
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)			48.52	97.05	242.62	363.93	485.24			
KPI	**The percentage of interprovincial busses electrified**		10%	20%	50%	75%	100%			
	E-Mobility	**Provincial Bus Electrification**	none	None	10% of the Bus Fleet	30% of the Bus Fleet	100% of the Bus Fleet			

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	**2031 – 2035**	**2036 - 2040**	**2041 - 2045**	**2046 - 2050**			
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)			-	-	54.60	163.81	546.04			
KPI	**The percentage of provincial busses electrified**				10%	30%	100%			
		Private vehicles electrification	Approximately 457,000 private vehicles and 16000 freight vehicles per year in 2030	5% / annum increase from the base figure (25% increase for 5 years)	5% / annum increase from the base figure (25% increase for 5 years)	5% / annum increase from the base figure (25% increase for 5 years)	5% / annum increase from the base figure (25% increase for 5 years)			
			1,853.22	2,316.53	2,779.84	3,243.14	3,706.45			
KPI	**No. of electric vehicles imported**		Approximately 457,000 private vehicles and 16000 freight vehicles per year in 2030	5% / annum increase from the base figure (25% increase for 5 years)	5% / annum increase from the base figure (25% increase for 5 years)	5% / annum increase from the base figure (25% increase for 5 years)	5% / annum increase from the base figure (25% increase for 5 years)			
Total GHG Emission Reduction by the end of the 5- year period (1000 tonnes CO2e) Transport Sector			**4,559.20**	**5,230.91**	**6,125.24**	**7,319.88**	**8,445.07**			
INDUSTRY SECTOR										
Industry sector IPPU GHG emission Reduction	**Cement industry** process emission reduction through the Promotion of sustainable consumption at end-user level, Resource Efficient Cleaner Production (RECP) at supplier	Activities relevant to given strategy will be implemented throughout the 25 years period at different scales subjected to the availability of the resource, technology and business environment	Implementation of appropriate cleaner production programmes in cement manufacturing process with especial focus on raw material input optimization. Raw material switching to low /no GHG emission types, Switching from Ordinary Portland Cement to Low Carbon Cement, Clinker factor reduction, Introduce Sustainable consumption (SCP) practices at end user level, Adopting circular economic practices,	INSEE Cement Industry, Ministry of industries. Sri Lanka Sustainable Development Council, Ministry of environment, GSMB, Climate change secretariat, Technology service providers, NGOs and multilateral donor agencies, Forest project owners and Renewable energy project owners with carbon offsetting facilities	Sustainable financial facilities, Technology sharing / updating opportunities, Sustainable development focused human resources development programmes, R&D facilitators / agencies	Mineral / Cement industry focused policy guidelines, Emission management national policies / guidelines, National action plans and MRV system and suitable economic instruments such as taxes and incentives	**Cement industry** process emission reduction through the Promotion of sustainable consumption at end-user level, Resource Efficient Cleaner Production (RECP) at supplier level, new technology adaptation and emission offsetting activities	Activities relevant to given strategy will be implemented throughout the 25 years period at different scales subjected to the availability of the resource, technology and business environment	Implementation of appropriate cleaner production programmes in cement manufacturing process with especial focus on raw material input optimization. Raw material switching to low /no GHG emission types, Switching from Ordinary Portland Cement to Low Carbon Cement, Clinker factor reduction, Introduce Sustainable consumption (SCP) practices at end user level, Adopting	INSEE Cement Industry, Ministry of industries. Sri Lanka Sustainable Development Council, Ministry of environment, GSMB, Climate change secretariat, Technology service providers, NGOs and multilateral donor agencies, Forest project owners and Renewable energy project owners with carbon offsetting facilities

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
	level, new technology adaptation and emission offsetting activities		Emission offsetting project						circular economic practices, Emission offsetting project	
Total GHG Emission Reduction by the end of the 5- year period (1000 tonne CO2e) Industry IPPU Sector; Cement subsector			5059.4963	2896.8589	1708.0553	670.8130	101.5623			
KPI	Cement industry IPPU emission reduction is highly dependent on process, raw material, geography, business environment etc. hence specific quantitative GHG emission reduction potentials are not yet defined by the relevant industry. Therefore the proposed KPIs are highly subjective to the future technological deviations. The proposed KPIs are the % out of total direct CO2e (calculated) reduction relevant to the 2025 – 2050 time horizon.		48%	28%	16%	6%	1%			
	Lime manufacturing industry process emission reduction through Promotion of sustainable consumption at end-user level, Resource	Activities relevant to given strategy will be implemented throughout the 25 years' period at different scales subjected to the availability of resource, technology and business environment	Introducing Consumer level consumption reduction /demand reduction programmes, Adopting Cleaner production and SCP programmes at producer level, R&D activities for alternate materials with low carbon emission factors, R&D programmes with the focus of low emission and circular economic opportunities, Introducing Lime industry productivity improvement programmes					Individual lime industries, Lime producers' consortiums and Co-Op societies, SME Sector related Government ministries & agencies, GSMB, Sri Lanka Sustainable Development Council, Ministry of environment,	Sustainable financial facilities, Technology sharing / updating opportunities, Sustainable development focused human resources development programmes,	Lime industry focused policies, action plans and MRV system and suitable economic instruments such as taxes and incentives

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
	Efficient Cleaner Production (RECP) at producer level, new technology adaptation and emission offsetting							Climate change Secretariat, CEA, IDB, Development banks, Technology service providers, Multilateral donor agencies, Forest Project owners and Renewable energy project owners with carbon offsetting facilities		
Total GHG Emission Reduction by the end of the 5- year period (1000 tonne CO2e) Industry IPPU Sector; Cement subsector			**2179.4753**	**1247.8777**	**735.7777**	**288.9656**	**43.7499**			
KPI	Lime production industry IPPU emission reduction is highly dependent on process, geography, business environment etc. hence specific quantitative GHG emission reduction potentials are not yet defined by the relevant industry. Therefore the proposed KPIs are highly subjective to the future technological deviations. The proposed KPIs are the % out of total direct CO2e (calculated) reduction relevant to the 2025 – 2050 time horizon.		21%	12%	7%	3%	0.4%			
	Solvent use process emission reduction through Promotion of sustainable	Activities relevant to given strategy will be implemented throughout the 25 years period at different scales subjected to the availability of resource,	Introducing Consumer level solvent consumption reduction /demand reduction programmes, Adopting Cleaner production and SCP programmes at end-user level, Promotion of 3R strategies in solvent use, R&D activities for alternate solvents with low carbon emission factors, R&D programmes with the focus of low emission and circular economic opportunities, introducing green supply chain based solvent recovery business opportunities					Individual solvent users, Solvent producers / importers / distributors / retailers, SME Sector related Government ministries & agencies,	Sustainable financial facilities, Technology sharing / updating opportunities, Sustainable development focused human resources development programmes,	Solvent use industry / business focused policies, action plans and MRV system and suitable economic instruments such as taxes and incentives

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
	consumption at end-user level, Resource Efficient Cleaner Production (RECP) at end user level, New / Green technology adaptation and Circular economic opportunities	technology and business environment						Sri Lanka Sustainable Development Council, Ministry of environment, Climate change Secretariat, CEA, IDB, Development banks, Technology service providers, Multilateral donor agencies, R&D agencies, Universities, Technical collages		
Total GHG Emission Reduction by the end of the 5- year period (1000 tonne CO2e) Industry IPPU Solvent use sub sector			**311.3536**	**178.2682**	**105.1111**	**41.2808**	**6.2499**			
KPI	Solvent use IPPU emission reduction is highly dependent on process, geography, business environment etc. hence specific quantitative GHG emission reduction potentials are not yet defined by the relevant industry. Therefore the proposed KPIs are highly subjective to the future technological deviations. The proposed KPIs are the % out of total direct CO2e (calculated) reduction relevant to the 2025 – 2050 time horizon.		48.5%	27.8%	16.4%	6.4%	1.0%			

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
	Glass manufacturing industry: Emission reduction through Promotion of sustainable consumption at consumer / end-user level, Resource Efficient Cleaner Production (RECP) at end user level, New / Green technology adaptation and Circular economic opportunities	Activities relevant to given strategy will be implemented throughout the 25 years period at different scales subjected to the availability of resource, technology and business environment	• National level and sub national level Glass product green / sustainable supply chain development, • National level promotion of 3R based supply chains to minimize the use of raw silica sand used glass production, • Adaptation of CP technologies to local glass manufacturing industry, • Maximizing the use of culets in local glass industry • Emission offsetting projects, • Carbon capture and storage (CCS) Carbon capture, storage and use (CCSU) processes.					All glass manufacturing industries in Sri Lanka, Sri Lanka Sustainable Development Council, Ministry of environment, Climate change Secretariat, GSMB, CEA, IDB, Development banks, Technology service providers, Multilateral donor agencies, R&D agencies, Universities,	Sustainable financial facilities, Technology sharing / updating opportunities, Sustainable development focused human resources development programmes,	**Glass manufacturing industry:** Emission reduction through Promotion of sustainable consumption at consumer / end-user level, Resource Efficient Cleaner Production (RECP) at end user level, New / Green technology adaptation and Circular economic opportunities
Total GHG Emission Reduction by the end of the 5- year period (1000 tonne CO2e) Industry IPPU Solvent use sub sector			155.6768	89.1341	52.5555	20.6404	3.1250			
KPI	Glass manufacturing industry IPPU emission reduction is highly dependent on process, geography, business environment etc. hence specific quantitative GHG emission reduction potentials are not yet defined by the relevant industry. Therefore the proposed KPIs are		48.5%	27.8%	16.4%	6.4%	1.0%			

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
	highly subjective to the future technological deviations. **The proposed KPIs are the % out of total direct CO2e (calculated) reduction relevant to the 2025 – 2050 time horizon.**									
	Ceramic Industry material use and process related Emission reduction through Promotion of sustainable consumption at consumer / end-user level, Resource Efficient Cleaner Production (RECP) at end user level, New / Green technology adaptation and Circular economic opportunities	Activities relevant to given strategy will be implemented throughout the 25 years period at different scales subjected to the availability of the resource, technology and business environment	• Introducing Consumer level product consumption reduction /demand reduction programmes (SCP based), • Adopting Cleaner production and SCP programmes at production level, • R&D activities to use alternative materials with low carbon emission factors, • R&D programmes with the focus of low emission and circular economic opportunities, • Introducing Ceramic industry productivity improvement programmes • Emission offsetting projects, Carbon capture and storage (CCS) Carbon capture, storage and use (CCSU) processes.					All ceramic product (Wall tile, Floor tiles, Chinaware / porcelain Industries in Sri Lanka, Ministry of industries. BOI, Sri Lanka Sustainable Development Council, Ministry of environment, CEA, GSMB, Climate change secretariat, Technology service providers, NGOs and multilateral donor agencies, Forest Project's owners and Renewable energy project owners with carbon offsetting facilities	Sustainable financial facilities, Technology sharing / updating opportunities, Sustainable development focused human resources development programmes,	Ceramic industry focused policies & action plans and MRV system and suitable economic instruments such as taxes and incentives

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
Total GHG Emission Reduction by the end of the 5- year period (1000 tonne CO2e) Industry IPPU Solvent use sub sector			77.8384	44.5671	26.2778	10.3202	1.5625			
KPI	Ceramic industry IPPU emission reduction is highly dependent on process, geography, business environment etc. hence specific quantitative GHG emission reduction potentials are not yet defined by the relevant industry. Therefore the proposed KPIs are highly subjective to the future technological deviations. The proposed KPIs are the % out of total direct CO2e (calculated) reduction relevant to the 2025 – 2050 time horizon.		48.5%	27.8%	16.4%	6.4%	1.0%			
	Bakery industry / bread production related raw material use and process related Emission reduction through the Promotion of sustainable consumption at consumer / end-user level,	Activities relevant to given strategy will be implemented throughout the 25 years period at different scales subjected to the availability of the resource, technology and business environment	• Introducing Consumer level product consumption reduction /demand reduction / waste minimization programmes (SCP based), • Adopting Cleaner production and SCP programmes at production level, • R&D activities to use alternative materials with low carbon emission factors (such as low carbon yeast strains), R&D programmes with the focus of low emission process in bakery industry					All Bakery Industries in Sri Lanka, Ministry of industries. Sri Lanka Sustainable Development Council, Ministry of environment, CEA, SLSI, ITI, Climate change secretariat, Bakery technology service providers, NGOs and multilateral donor agencies,	Sustainable financial facilities, Technology sharing / updating opportunities, Sustainable development focused human resources development programmes,	Food sector industry focused policies & action plans and MRV system and suitable economic instruments such as taxes and incentives

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	**2031 – 2035**	**2036 - 2040**	**2041 - 2045**	**2046 - 2050**			
	Resource Efficient Cleaner Production (RECP) at producer level, New / Green technology adaptation									
Total GHG Emission Reduction by the end of the 5- year period (1000 tonne CO2e) Industry IPPU Solvent use sub sector			**0.2335**	**0.1337**	**0.0788**	**0.0307**	**0.0047**			
KPI	Bakery industry IPPU emission reduction is highly dependent on process, geography, business environment etc. hence specific quantitative GHG emission reduction potentials are not yet defined by the relevant industry. Therefore the proposed KPIs are highly subjective to the future technological deviations. **The proposed KPIs are the % out of total direct CO2e (calculated) reduction relevant to the 2025 – 2050 time horizon.**		48.5%	27.8%	16.4%	6.4%	1.0%			
Total GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)			**7783.84**	**4456.70**	**2627.77**	**1032.02**	**156.24**			
WASTE SECTOR										

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	**2031 – 2035**	**2036 - 2040**	**2041 - 2045**	**2046 - 2050**			
WASTE SECTOR	Biochar for Carbon Sequestra tion	Using biochar for daily cover in landfills and open dumps	Daily cover for open dumpsite with Biochar (continues until 2050	Daily cover for open dumpsite with Biochar (continues until 2050	Daily cover for open dumpsite with Biochar (continues until 2050	Daily cover for open dumpsite with Biochar (continues until 2050	Daily cover for open dumpsite with Biochar (continues until 2050	SLLDC, WMA-WP, LAs	-Human resources -Technology -Policy -Strategy -Infrastructure -Resource Assessment -Awareness on the downside of open dump	Budget allocation by Las Necessary equipment for Biochar production (Pyrolizers, conveyors belts, movers, etc) Necessary equipment for operation of open dumps Insufficient human resource/experts Proper data management system Policy on decommissioning open dumps Minimal infrastructure Land extent
GHG Emission Reduction by the end of the 5 years of period (1000 tonnes CO2e)			76.3	95.3	116.2	139.1	164.1			
KPI	Area of open dump to be filled with landcover		15%	25%	40%	55%	75%			
	Waste managem ent	MSW growth reduction with 3R practice & promote recycling and use of recycled materials	3R practice collection and reduction of waste generation at source. These practices are extended from NDC and improved to continue until 2050	3R practice collection and reduction of waste generation at source. These practices are extended from NDC and improved to continue until 2050	3R practice collection and reduction of waste generation at source. These practices are extended from NDC and improved to continue until 2050	3R practice collection and reduction of waste generation at source. These practices are extended from NDC and improved to continue until 2050	3R practice collection and reduction of waste generation at source. These practices are extended from NDC and improved to continue until 2050	NSWMSC, SLLDC, WMA, LAs	-Ban Single use plastics and tetra packs -EPR implementation -Continuous awareness programs -Strategy to monitor segregation -Human resources -Recycling machinery	-Hard plastic recycling -Strong PPP -Infrastructure to reduce mixing after segregation -Mechanical Sorters -Recycler empowerment -Training and Financial support

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)			11.3	13.2	15.2	17.8	22.1			
KPI	No of recycling yards for each province		2 recycling yards for each province	5 recycling yards for each province	1 recycling yard for each district	2 recycling yards for each district	Recycling yards for each LAs			
	GHG Capture	Methane recovery for SynGas production from open dumps and sanitary landfills		Recovery of GHG from Open dumpsite to use it for the production of Syn Gas (Synthesis Gas) - 10% Implementation	Recovery of GHG from Open dumpsite to use it for the production of Syn Gas (Synthesis Gas) - 20% implementation	Recovery of GHG from Open dumpsite to use it for the production of Syn Gas (Synthesis Gas) - 35% Implementation	Recovery of GHG from Open dumpsite to use it for the production of Syn Gas (Synthesis Gas) - 50% Implementation	NSWMSC, SLLDC, WMA, LAs and Private Sector	-Human resources -Technology -Policy -Strategy -Infrastructure for GHG collection & SynGas production	-Unavailable of feasible study in Sri Lanka -Infrastructure to collect the gas -Production plants to SynGas
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)				0.2	0.4	0.6	0.7			
KPI	Production and sale of SynGas			Commissioning of SynGas production plant & Start production	Market and sell the 10 tonnes CO_2e syngas	Sell the 15 tonnes CO_2e syngas	Sell the 20 tonnes CO_2e syngas			
	Phytoremediation & Biochar for Carbon Sequestration	Constructed wetland for wastewater treatment and reuse treated wastewater for greening (VSSFCW)		Implementing a centralized Vertical Sub Surface Flow Constructed Wetland (VSSFCW) at a strategic location in the Western province to purify the wastewater biologically and re use the water to enrich the groundwater				CEA, Las, CMC, BOI, Provate Sector	-Emission accounting principles -Infrastructure for VSSFCW and sludge removal facilities -Storm & Sewer network -Application of night soil	-Unavailable of feasible study in Sri Lanka -Insufficient human resource/ experts -Improper design of storm & sewer network
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)				97.6	95.3	93.1	90.8			

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
KPI	Quantity of treated wastewater reuse Vertical Subsurface Flow Constructed Wetland (VSSFCW)			3 VSSFCW to achieve treated wastewater reuse rate of 50%	5 VSSFCW to achieve treated wastewater reuse rate of 60%	15 VSSFCW to achieve treated wastewater reuse rate of 75%	25 VSSFCW to achieve treated wastewater reuse rate of 90%			
	E-mobility	Transforming the waste collection garbage trucks into electric trucks			Implementation of Electric vehicle for waste transportation and Route Optimization using Internet of Things (IoT)- The vehicles to be charged with renewable energy			NSWMSC, WMA, Las	-Dump Trucks Compactors -Renewable Energy -Charging Stations -IoT implementations	-Financial allocations by the Las -Renewable energy production
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)					0.1	0.1	0.1			
KPI	No of the Garbage trucks converted to electric trucks				100	200	300			
	Energy Production from waste	Introducing waste to energy plants for other provinces			WtE plant 1 is to be implemented strategically at a location covering Central & North Central provinces to ensure energy production from waste that could not recycle or reuse.	Two WtE plants are to be implemented to replace the Coal power plants with carbonstcks , to ensure the net GHG emission reduction in the content of the net gain from moving towards sustainable practices.		Ministry of Power & Energy,CEB, NSWMSC, SLLDC, WMA, LAs and Private Sector	-Human resources -Technology -Policy -Strategy -Infrastructure -Land Capacity Building	-Financial allocations by the Las -Lack of feasibility study in Sri Lanka
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)					144.4	281.1	271.5			
KPI	Parentage of waste treated in waste to energy plants				50%	75%	100%			

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
	Biochar for Carbon Sequestration	Establishing sanitary landfills for residual wastes					A Sanitary landfill is to be introduced strategically to dispose of the unavoidable waste generated (fuel to the WtE plants.	NSWMSC, SLLDC, WMA, CEA, LAs	-Human resources -Technology -Policy -Strategy Infrastructure -Land area in strategical location	-Financial allocations by the LAs -Limited land area
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)							62.9			
KPI	No of new sanitary landfill						Construction of sanitary landfill			
Emission Reduction Not Estimated due to lack of Data										
	Encouragement policies	Refunds & incentives for proper waste management	Refunds & incentives for proper waste management					LAs	-Financial resources -Human resources -Technology and infrastructure -Awareness and education -Regulatory framework	-Financial allocations by the Las -Regulatory framework
KPI	No of automated refund system machines in operation		10	25	50	75	100			
	Material efficiency	Promote circular economy in supply chains and construction industry	Promote circular economy in supply chains					Department of Buildings SLSEA SLAMERP SLAEA UNDP WMA	-Material Recovery and recycling facilities -Reverse logistics system -Data analytic tools -Renewable Energy Sources -Collaborations and Partnerships -Design for Circularity -Consumer education and Engagement	-Data analytic tools -Renewable Energy Sources -Financial allocations by the Las -Design for Circularity -Knowledge gap
KPI	Percentage of companies adopting circular economy practices		10%	20%	30%	40%	50%			

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
	Waste managem ent	Efficient waste management	Efficient waste management					LAs	-Financial resources -Human resources -Technology and infrastructure -Awareness and education	-Awareness and education
KPI	No of local authorities implementing waste reduction and recycling program		10	20	30	40	50			
	GHG Capture	Biogas from fecal sludge at community level		Introducing Biogas from fecal sludge at community level				LAs BOI	-Fecal Sludge Collection -Biogas Plant Infrastructure -Expertise and Training -Feedstock Management -Gas Utilization -Financing	-Biogas Plant Infrastructure -Awareness and education -Financial allocations by the Las -Policy and Regulatory Gaps
KPI	No of community Biogass plants			5 communities	10 communities	15 communities	20 communities			
	Value addition to waste	Hybrid fertilizer production and Subsidy free community-based composting	Hybrid fertilizer production from MSW and Subsidy free community-based composting					NSWMSC SLLDC WMA LAs	-Waste collection infrastructure -MSW treatment and processing equipment -Composting infrastructure -Technical expertise -Financial resources -Education and awareness	-Financial resources -Education and awareness
KPI	No of tons of hybrid fertilizer produced per year		500	1000	1500 tons	2000 tons	2500 tons			
	Waste managem ent	Introducing the waste management activities and the emissions reduction opportunities	Introducing the waste management activities and the emissions reduction opportunities					LAs	-Waste management infrastructure -Emissions monitoring equipment -Technical expertise -Financial resources -Regulatory framework -Education and awareness	-Emissions monitoring equipment -Technical expertise -Financial resources -Regulatory framework

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	**2031 – 2035**	**2036 - 2040**	**2041 - 2045**	**2046 - 2050**			
KPI	No. of waste management activities introduced		5	10	15	20	25			
	Research on Carbon Capture	Promoting zero-carbon innovations				Promoting zero-carbon innovations through allowing NRC grants		NRC	-Funding -Technical expertise -Regulatory framework -Partnerships and collaboration -Research And Development -Education and training -Public Policy Support	-Funding -Policy Support Regulatory framework
KPI	No. of NRC grants awarded					Award 2 NRC grants	Award 5 NRC grants			
	Knowledge Building and Awareness	Community participation, empowerment, and capacity building						LAs	-Funding -Technical expertise -Regulatory framework -Partnerships and collaboration -Research And Development -Education and training -Public Policy Support	-Funding -Policy Support Regulatory framework
KPI	No of skill development opportunities provided		3 skills development opportunities	6 skills development opportunities	9 skills development opportunities	12 skills development opportunities	15 skills development opportunities			
Total GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e) Waste Sector			**87.6**	**206.3**	**371.6**	**531.8**	**612.2**			
AGRICULTURE SECTOR										

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
Agriculture Sector	Reduce methane emission from paddy fields by removing rice straws and through good management practices	Export of paddy straw Manufacture paper Manufacture boards Production of bio fuel Packaging industry	Paddy land extent target: 147,750ha	Paddy land extent target: 197,000 ha	Paddy land extent target: 246,250 ha	Paddy land extent target: 197,000 ha	Paddy land extent target: 98,500 ha	National Paper Company Ltd,, Valaichchenai and Embilipitiya, Durra Building Systems (Pvt) Ltd	Incentives extension officers Funding for research and development	Lack of necessary policies
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)			**494**	**696**	**873**	**1024**	**1145**			
KPI	**Annual (yala and maha) paddy extent which produces paddy straws (ha)**		147,750	197,000	246,250	197,000	98,500	Department of Census and Statistics, Department of Agriculture		
	Reduce CH_4 emission from livestock by improving feed quality and animal comfort Reduce methane emission	Feed quality improvement Night feeding and supply of water Animal comfort improvement (heat reduction, free roaming)	Target No. of heads (neat cattle/Goat/Sheep) 146278	Target No. of heads (neat cattle/Goat/Sheep) 195037	Target No. of heads (neat cattle/Goat/Sheep) 243796	Target No. of heads (neat cattle/Goat/Sheep) 195037	Target No. of heads (neat cattle/Goat/Sheep) 97519	Department of Animal Production and Health, National Livestock Development Board, Market Oriented Dairy Project	Funding for Research and Development Incentives for extension workers	Lack of policy initiatives

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	**2031 – 2035**	**2036 - 2040**	**2041 - 2045**	**2046 - 2050**			
	from livestock by improving feed quality and animal comfort.									
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)			**319**	**455**	**573**	**675**	**758**			
KPI	**Number of animals treated**		146278	195037	243796	195037	97519			
	Reduce N_2O emission in soils due to microbial activities	Manure management Soil tillage reduction	N2O reduction 0.95 Giga tonnes	N2O reduction 1.27 Giga tonnes	N2O reduction 1.58 Giga tonnes	N2O reduction 1.27 Giga tonnes	N2O reduction 0.63 Giga tonnes	Department of Agriculture	Funding for Research and development Incentives for extension workers	Lack of necessary policies
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)			**724**	**1014**	**1265**	**1481**	**1664**			
KPI	**Paddy extent for soil N_2O reduction**		69,796	93,061	116,327	93,061	46,531			
KPI	**Number of animals with manure management**		146278	195037	243796	195037	97519			
	Use alternatives to Chemical fertilizer for reducing N_2O emission:	Reduction of artificial fertilizer application	Reduction of fertilizer: Urea 31,287 tonnes	Reduction of fertilizer: Urea 41,717 tonnes	Reduction of fertilizer: Urea 52,146 tonnes	Reduction of fertilizer: Urea 41,717 tonnes	Reduction of fertilizer: Urea 20,858 tonnes	Department of Agriculture, Fertilizer Secretariat, Fertilizer Cooperation, Private sector (CIC, Baurs)	Funding for research and development in organic farming sector Seeds and new variety development for organic farming	Lack of funds and necessary policy initiatives

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	**2031 – 2035**	**2036 - 2040**	**2041 - 2045**	**2046 - 2050**			
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)			**65**	**91**	**114**	**134**	**150**			
KPI	**Reduction of urea import tonnes per year**		31,287	41,717	52,146	41,717	20,858			
Total GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e) Agriculture Sector			**1,602**	**2,256**	**2,825**	**3,314**	**3,717**			
Carbon sequestration	Establishment of green hedges	**Land extent (in '000 ha) covered in green hedges**	2,117	5,013	8,822	12,160	14,471			
		Carbon sequestration in CO_2 Equivalent '000 Mt	-6	-8	-10	-9	-6			
KPI	**Land extent (in '000 ha) covered in green hedges**		2,117	5,013	8,822	12,160	14,471			
Total carbon sequestration by the end of the 5-year period (1000 tonnes CO2e) Agriculture Sector			**-6**	**-8**	**-10**	**-9**	**-6**			
FORESTRY SECTOR										
	Reduce GHG emissions from deforestation and loss of ecosystems in		Limiting the deforestation rate to 5000 ha/yr	Reducing the deforestation rate up to 2000 ha/yr	Reducing the deforestation rate up to 500 ha/yr	Reducing the deforestation rate up to 100 ha/yr	Reducing the deforestation rate to 0 ha/yr	Forest Department	Funds to be used as subsidies for the home gardeners	Poor implementation of the policies, laws and non adherence of the sectoral plans to the National Physical Plan which details the areas to be conserved and areas to be developed.

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	**2031 – 2035**	**2036 - 2040**	**2041 - 2045**	**2046 - 2050**			
	trees outside forests									
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)				450	675	735	750			
KPI	**Extent of forests removed per year**		5000 ha/yr	2000 ha/yr	500 ha/yr	100 ha/yr	0 ha/yr			
		2. Limiting the fragmentation of the coconut lands	Limit the fragmentation of the coconut lands at the present rate of 1705 ha/yr	Limit to the fragmentation of the coconut lands at the present rate of 1705 ha/yr	Limit to the fragmentation of the coconut lands at the present rate of 1705 ha/yr	Limit to the fragmentation of the coconut lands at the present rate of 1705 ha/yr	Limit to the fragmentation of the coconut lands at the present rate of 1705 ha/yr	Coconut Cultivation Board		Poor implementation of the policies, laws and non-adherence of the sectoral plans to the National Physical Plan which details the areas to be conserved and areas to be developed.
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)			-	-	-	-	-			
KPI	**Extent of coconut plantations removed per year**		1705 ha/yr	1705 ha/yr	1705 ha/yr	1705 ha/yr	1705 ha/yr			
		3. Conservation of mangroves	Conserve the mangroves so that there would not be any removal/loss/degradation	Conserve the mangroves so that there would not be any removal/loss/degradation	Conserve the mangroves so that there would not be any removal/loss/degradation	Conserve the mangroves so that there would not be any removal/loss/degradation	Conserve the mangroves so that there would not be any removal/loss/degradation	**Forest Department** IUCN, CC&CRMD UN IUCN Other NGOs working on mangrove conservation and planting Academia		There is no policy/legislation regards home gardens and therefore no institution is responsible for home gardens
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e)			25	24	23	22	21			
KPI	**Extent of mangrooves removed per year**		0	0	0	0	0			
		4. Ensure that the home gardens will not be fragmented and converted to other land uses	Through Private Public Partnerships ensure that the home gardens will not be fragmented and converted to other land uses	Through Private Public Partnerships ensure that the home gardens will not be fragmented and converted to other land uses	Through Private Public Partnerships ensure that the home gardens will not be fragmented and converted to other land uses	Through Private Public Partnerships ensure that the home gardens will not be fragmented and converted to other land uses	Through Private Public Partnerships ensure that the home gardens will not be fragmented and converted to other land uses	**Department of Agriculture** Forest Department Dept of Export Agriculture	Funds to be used as subsidies for the home gardeners	

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
								Academia		
GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e			423	445	468	492	517			
KPI	**Extent converted to other land uses per year**		0	0	0	0	0			
Total GHG Emission Reduction by the end of the 5-year period (1000 tonnes CO2e) Forestry Sector			**-2,923**	**678**	**1,162**	**1,578**	**1,774**			
	Increase the carbon Sequestration by trees by conservation of existing trees, increasing the quality of natural forests and plantations and increasing the tree cover	1. Conserve the existing natural forests, increase quality of natural forests and plant additional trees	Conserve the existing natural forests Increase the quality of natural forests and plantations. Plant 1805 ha/yr as forest plantations, river and catchment reservations, vacant areas in tea plantations etc. Newly plant/restore 7407 ha of land released under the category 'Other State Forests'	Conserve the existing natural forests Increase the quality of natural forests and plantations. Plant 1805 ha/yr as forest plantations, river and catchment reservations, vacant areas in tea plantations etc. Newly plant/restore 7407 ha of land released under the category 'Other State Forests'	Conserve the existing natural forests Increase the quality of natural forests and plantations. Plant 1805 ha/yr as forest plantations, river and catchment reservations, vacant areas in tea plantations etc. Newly plant/restore 7407 ha of land released under the category 'Other State Forests'	Conserve the existing natural forests Increase the quality of natural forests and plantations. Plant 1805 ha/yr as forest plantations, river and catchment reservations, vacant areas in tea plantations etc. Newly plant/restore 7407 ha of land released under the category 'Other State Forests'	Conserve the existing natural forests Increase the quality of natural forests and plantations. Plant 1805 ha/yr as forest plantations, river and catchment reservations, vacant areas in tea plantations etc. Newly plant/restore 7407 ha of land released under the category 'Other State Forests'	Forest Department, MASL, Ministry of Plantation Industries with special reference to Regional Plantation Companies and SLSPC Private sector, academia, NGOs Private sector, academia, NGOs Coconut Research Institute	Funds for planting, boundary demarcation and protection of existing natural forests and plantations and increasing the quality of the forest Funds for raising forest Funds for raising forest Funds Lands Funds lands Lands, funds	Dearth of funds, Dearth of lands to plant as there is competition between reforestation/afforestation/restoration and short term economic pursuits Dearth of funds, Dearth of lands to plant as there is competition between reforestation/afforestation/restoration and short term economic pursuits Dearth of funds, Dearth of lands to plant as there is competition between reforestation/afforestation/restoration and short term economic pursuits

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
Increased carbon sequestration by the end of the 5-year period (1000 tonnes CO_2e)			37	528	845	1,016	1,146			
KPI	The area of forest plantations		1805 ha/yr	1805 ha/yr	1805 ha/yr	1805 ha/yr	1805 ha/yr			
	Replanted/restored per year for all land uses		7407 ha	7407 ha	7407 ha	7407 ha	7407 ha			
		2. Total trees outside forest including home gardens, coconut plantation, tea plantations and urban green cover with areas of avenue plants	Increase the coconut lands by 80937 ha/yr Increase the urban/avenue plants by 500000 plants/yr Maintain the annual increase of tea lands which is 15000 ha/yr	Increase the coconut lands by 80937 ha/yr Increase the urban/avenue plants by 500000 plants/yr Maintain the annual increase of tea lands which is 15000 ha/yr	Increase the coconut lands by 80937 ha/yr Increase the urban/avenue plants by 500000 plants/yr Maintain the annual increase of tea lands which is 15000 ha/yr	Increase the coconut lands by 80937 ha/yr Increase the urban/avenue plants by 500000 plants/yr Maintain the annual increase of tea lands which is 15000 ha/yr	Increase the coconut lands by 80937 ha/yr Increase the urban/avenue plants by 500000 plants/yr Maintain the annual increase of tea lands which is 15000 ha/yr	Coconut Cultivation Board Forest Department Ministry of Urban Development UDA Tea Cultivation Board, RPC, SLSPC	Funds for planting, boundary demarcation and protection of existing natural forests and plantations and increasing the quality of the forest Funds for raising forest Funds for raising forest Funds Lands Funds lands Lands, funds	There is competition for land from real estate purposes Pest and diseases in coconut which make the plantations not economically lucrative Lack of space in the urban areas is a significant problem here. There is no policy/regulation to allow the extents of greenery in urban spaces and these needs to be factored in to the UDA act.
Increased carbon sequestration by the end of the 5-year period (1000 tonnes CO_2e)			1,562	1,614	1,669	1,726	1,624			
KPI	Replanted/restored per year for all land uses		80937 ha/yr	80937 ha/yr	80937 ha/yr	80937 ha/yr	80937 ha/yr			
	Increased area with urban/avenue plants		500000 plants/yr	500000 plants/yr	500000 plants/yr	500000 plants/yr	500000 plants/yr			
	Increased area with tea lands		15000 ha/yr	15000 ha/yr	15000 ha/yr	15000 ha/yr	15000 ha/yr			
		3. Blue Carbon Ecosystems	Plant 100 ha of mangroves/yr	Plant 100 ha of mangroves/yr	Plant 100 ha of mangroves/yr	Plant 100 ha of mangroves/yr	Plant 100 ha of mangroves/yr	CC&CRMD, IUCN, relevant NGOs, Private sector, Academia		Not all the mangrove areas are not protected and therefore had been succumbed to other land uses. Need to study all the mangroves areas and bring them under protection

Key Topic	Strategy	Activity	Time frame of the Actions					Responsibility	Resources Required	Gap of Resources
			2025 - 2030	2031 – 2035	2036 - 2040	2041 - 2045	2046 - 2050			
Increased carbon sequestration by the end of the 5-year period (1000 tonnes CO_2e)			62	94	125	154	183			
KPI	**Replanted/restored per year for all land uses**		100 ha	100 ha	100 ha	100 ha	100 ha			
Total Increased Carbon sequestration by the Forestry Sector by the end of the 5-year period (1000 tonnes CO2e)			**121**	**380**	**877**	**1,426**	**2000**			

SECTION 8: REFERENCES

Abayasiri, S. & Ranasinghe, DMSHK (2000) Assessment of forest plantation (Tectona grandis) in acting as carbon sink to reduce the green house effect in the atmosphere in Sri Lanka. In Proceedings of the 5th Annual Symposium of Forestry and Environmental Science, University of Sri Jayewardenepura, Nugegoda, Sri Lanka

Amarasekera, L.A.M.C. and Ranasinghe, D.M.S.H.K. (2006) "Assessment of rates of soil carbon sequestration by litter decomposition of Yagirala Forest Reserve and Horton Plains Natural Forest in low country wet zone and montane zone of Sri Lanka", Proceedings of the 62nd Annual Sessions of Sri Lanka Association for Advancement of Science (SLAAS), 10-15 December, 2006, Sri Lanka.

APO (2007) *Solid Waste Management: Issues and Challenges in Asia*, *Asian Productivity Organization (APO)*. Available at: www.apo-tokyo.org.

Benlemlih, M., Assaf, C. and El Ouadghiri, I. (2022) "Do political and social factors affect carbon emissions? Evidence from international data," *Applied Economics*, 54(52), pp. 6022–6035. Available at: https://doi.org/10.1080/00036846.2022.2056128.

Boserup, E. (1970). *Women's Role in Economic Development*, Trowbridge, UK: Cornwell Press.

Benlemlih, M., Assaf, C. and El Ouadghiri, I. (2022) "Do political and social factors affect carbon emissions? Evidence from international data," *Applied Economics*, 54(52), pp. 6022–6035. Available at: https://doi.org/10.1080/00036846.2022.2056128.

Castañeda Camey, I., Sabater, L., Owren, C. and Boyer, A.E. (2020). *Gender-based violence and environment linkages: The violence of inequality*. Wen, J. (ed.). Gland, Switzerland: IUCN. 272pp.

CEB (2021) *Statistical Digest-2021*, Ceylon Electricity Board, Sri Lanka. https://ceb.lk/front_img/img_reports/1656311266CEB-Statistical-Digest-2021-cover.pdfDepartment of Census and Statistics (2012) *Census of population and housing 2012*. Baththaramulla: Department of Government Printing; 2012.

CEB (2022) *Draft Long Term Generation Expansion Planning Studies 2023- 2042*, The Generation Planning Unit, Transmission and Generation Planning Branch, Ceylon Electricity Board, Sri Lanka. https://www.pucsl.gov.lk/wp-content/uploads/2022/09/LTGEP-2023-2042_Full.pdf

Central Bank (2020). Annual Report. Available at: https://www.cbsl.gov.lk/sites/default/files/cbslweb_documents/statistics/otherpub/ess_2020_e1.pdf

Chathumini, K. K. G. L., Dassanayake, N. P., Preethika, D. D. P., Wadanambi, R. T., Wandana, L. S., & Arachchige, U. S. P. R. (2021). Agriculture and Greenhouse Gas Emissions. *Journal of Research Technology and Engineering*, *2*(2), 22–31

Chiu, A.C., Xiao, Y. (2019). Physical Modelling of Mitigating Methane Emission from Biochar Modified MSW Landfill Cover. In: Zhan, L., Chen, Y., Bouazza, A. (eds) Proceedings of the 8th International Congress on Environmental Geotechnics Volume 3. ICEG 2018. Environmental Science and Engineering (). Springer, Singapore. https://doi.org/10.1007/978-981-13-2227-3_53

Climate Change Secretariat of the Ministry of Environment (2022) Third National Communication to the UNFCC

Climate Watch (2020) *GHG Emissions. Washington, DC*: World Resources Institute Available at: https://www.wri.org/initiatives/climate-watch

Climate watch (2020) *World Resources Institute*. Available at: https://www.wri.org/initiatives/climate-watch

CO_2 emissions by sector Our World in Data. Available at: https://ourworldindata.org/grapher/co-emissions-by-sector?country=~LKA

CO2 emissions from transport (% of total fuel combustion) - sri lanka Data. Available at: https://data.worldbank.org/indicator/EN.CO2.TRAN.ZS?locations=LK

CO2 emissions from transport (% of total fuel combustion) | Data. (n.d.). https://data.worldbank.org/indicator/EN.CO2.TRAN.ZS?end=2014

Council for Decarbonizing Transport in Asia (2022). The Path to Zero: A Vision for Decarbonised Transport in Asia –Overcoming Blind Spots and Enabling Change

Couth, R. and Trois, C. (2011) 'Waste management activities and carbon emissions in Africa', *Waste Management*, 31(1), pp. 131–137. Available at: https://doi.org/10.1016/j.wasman.2010.08.009.

Daniela Requena Suarez Danaë M. A. Rozendaal Veronique De Sy Oliver L. Phillips Esteban Alvarez-Dávila Kristina Anderson-Teixeira Alejandro Araujo-Murakami Luzmila Arroyo (2019) Estimating aboveground net biomass change for tropical and subtropical forests: Refinement of IPCC default rates using forest plot data, Volume 25 Issue 11, Wiley Publications

DAPH (2022) *The National Livestock Breeding Policy Guidelines and Strategies for Sri Lanka* Available at: https://faolex.fao.org/docs/pdf/srl169540.pdf

De Costa, W. and Suranga, H. (2012) Estimation of carbon stocks in forest plantations of Sri Lanka, Journal of the National Science Foundation of Sri Lanka, 40, 9-41

Demir, Ö. and Yapıcıoğlu, P. (2019) 'Investigation of GHG emission sources and reducing GHG emissions in a municipal wastewater treatment plant', *Greenhouse Gases: Science and Technology*, 9(5), pp. 948–964. Available at: https://doi.org/10.1002/ghg.1912.

Department of Census and Statistics (2012) *Census of Population and Housing*, *Department of Census and Statistics*. Colombo, Sri Lanka: Department of Census and Statistics Website. Available at:

http://www.statistics.gov.lk/Population/StaticalInformation/CPH2011/CensusPopulationHousing2012-FinalReport

Department of Census and Statistics (2021) *Crude Birth Rates & Crude Death Rates by Province, District & Sex 2020-2021*, *Department of Census and Statistics*. Colombo, Sri Lanka: Department of Census and Statistics Website. Available at: http://www.statistics.gov.lk/Population/StaticalInformation/VitalStatistics/CrudeBirthRatesCrudeDeathRatesProvinceDistrictSex2020-2021

Department of Census and Statistics, Ministry of Finance, Economic Stabilization and National Policies, Sri Lanka (2022)

DESA (2022) *World Population Prospects - Population Division - United Nations*. Available at: https://population.un.org/wpp/Graphs/DemographicProfiles/Line/144

Dhammika Perera (2021) Coconut Development Action Plan

Dharmakeerthi, R. S. (2013). Organic carbon stocks in rubber (*hevea brasiliensis*) growing soils of Sri Lanka and strategies to increase: A Review. *Journal of the Rubber Research Institute of Sri Lanka*, *93*, 16–36. https://doi.org/10.4038/jrrisl.v93i0.1864

Disaggregation of Petroleum Product Usage by End-Use Category by Sri Lanka Sustainable Energy Authority, 2016

Dissanayake, A and Ranasinghe, H. (2009) "Estimation of carbon stock of Kandyan Home gardens in Sri Lanka with special reference to Kandy and Matale Districts", Proceedings of the 14th International Forestry and Environment Symposium, Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Proceedings of the 50th Anniversary Academic Conference, University of Sri Jayewardenepura.

Dissanayake, A and Ranasinghe, H.and Wahala, S. (2009) "Estimation of carbon stock of Kandyan Home gardens in Sri Lanka with special reference to Kandy and Matale Districts", Proceedings of the 14th International Forestry and Environment Symposium, Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Proceedings of the 50th Anniversary Academic Conference, University of Sri Jayewardenepura.

Durbin M., 2017. Methane Emissions Due to Paddy Rice Farming in Sri Lanka: Environmental, Social and Economically Sustainable Alternatives, College of Saint Benedict, Saint Johns University

EEA (2021). *Exploring the Social Challenges of Low-Carbon Energy Policies in Europe*, Briefing No.11, 2021, European Environment Agency, https://www.eea.europa.eu/publications/exploring-the-social-challenges-of

Ergas, C. and York, R. (2012) "Women's status and carbon dioxide emissions: A quantitative cross-national analysis," *Social Science Research*, 41(4), pp. 965–976. Available at: https://doi.org/10.1016/j.ssresearch.2012.03.008.

European commision (2020) 'Circular Economy Action Plan'.

FAO (2013a) Forest Resources Assessment Working Paper 183, Towards the Assessment of Trees Outside Forests

FAO (2013b) User Manual for Estimating GHG in Agriculture with EX-ACT Available at: https://www.fao.org/fileadmin/templates/ex_act/pdf/Technical_guidelines/EX-ACTUserManuaFinal_WB_FAO_IRD.pdf

FAO (2017) Food and Agriculture Organization of the United Nations. *Reducing enteric methane for improving food security and livelihoods*. Available at: https://www.fao.org/3/i5902e/i5902e.pdf

FAO, & New Zealand Agricultural Greenhouse Gas Research Centre. (2017) *Option for low emission development in the Sri Lanka dairy sector - Reducing enteric methane emissions for food security and livelihoods*. Rome 38 pp. https://www.fao.org/3/i7673e/i7673e.pdf

FAO. *Statistics* Available at: https://www.fao.org/statistics/en/

FAO, UNDP and UNEP (2017) Sri Lanka's Forest Reference Level submission to the UNFCCC

Ferronato, N. *et al.* (2019) 'Introduction of the circular economy within developing regions : A comparative analysis of advantages and opportunities for waste valorization', *Journal of Environmental Management*, 230(April 2018), pp. 366–378. Available at: https://doi.org/10.1016/j.jenvman.2018.09.095.

Ghaeli, M.R. (2019) "The role of gender in corporate governance: A state-of-art review," *Accounting*, 47(4), pp. 31–34. Available at: https://doi.org/10.5267/j.ac.2018.6.002.

Gobishankar, S. and Ranasinghe, D.M.S.H.K. (2021) Assessment of the Blue carbon stocks including Mangroves, Sea grasses and Salt marshes in Puttalam, North West Sri Lanka, Proceedings of the 25th International Forestry and Environment Symposium, 22-23 January 2021 Colombo in Sri Lanka,

Gouldson, A., Sudmant, A., Khreis, H., Papargyropoulou, E. (2018). *The Economic and Social Benefits of Low-Carbon Cities: A Systematic Review of the Evidence*. Coalition for Urban Transitions. London and Washington, DC. http://newclimateeconomy.net/content/cities-working-papers

Government of Sri Lanka (2019) 'National Policy on Sustainable Consumption & Production for Sri Lanka'. Available at: https://www.env.gov.lk/web/images/downloads/publications/other_publication/scp_policy/scp_policy_english_printing_new_a_5_1.pdf.

Green House Gas Protocol. (2014). *Global Warming Potential Values*. IPCC Fifth Assessment Report. Available at: https://ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values.pdf

Gunaruwan, T.L. and Gunasekara, W.N. (2016) 'Management of Municipal Solid Waste in Sri Lanka: A Comparative Appraisal of the Economics of Composting', *NSBM Journal of Management*, 2(1), p. 27. Available at: https://doi.org/10.4038/nsbmjm.v2i1.19.

Gunasena, C.P. (2020) Vertical expansion of human settlements for sustainable cascade ecosystems in the dry zone and the mountain regions of Sri Lanka. The Climate Change Magazine of Sri Lanka, Dec., pp.163–171. Available at https://www.env.gov.lk/web/images/pdf/divisions/climate_change_division/publications/NeelaHarithaMagazine_Vol_III_compressed.pdf

Gunasena, C. (2016). Micro catchment management planning for Tea small holders. www.academia.edu. Unpublished report [online] Available at: https://www.academia.edu/26366518/Micro_catchment_management_planning_for_Tea_small_holders

Hamrani, A., Akbarzadeh, A., & Madramootoo, C. A. (2020). Machine learning for predicting greenhouse gas emissions from agricultural soils. *Science of the Total Environment, 741*, 140338. https://doi.org/10.1016/j.scitotenv.2020.140338

Haque, F. (2017) "The effects of board characteristics and sustainable compensation policy on carbon performance of UK firms," *The British Accounting Review*, 49(3), pp. 347–364. Available at: https://doi.org/10.1016/j.bar.2017.01.001.

Huyer, S. (2016). Closing the Gender Gap in Agriculture. *Gender, Technology and Development*, *20*(2), 105–116. https://doi.org/10.1177/0971852416643872

IEA (2021) Net Zero by 2050 A Roadmap for the Global Energy Sector Available at: https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

Imbulana Arachchi, J. and Managi, S. (2021) "Preferences for energy sustainability: Different effects of gender on knowledge and importance," *Renewable and Sustainable Energy Reviews*, 141, p. 110767. Available at: https://doi.org/10.1016/j.rser.2021.110767.

IPCC (2006) *National Greenhouse Gas Inventories* Volume 3 Industrial Processes and Product Use Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol3.html

IPCC (2014) *Climate Change 2014: Synthesis Report* Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

IPCC (2021): *Summary for Policymakers*. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3−32, doi:10.1017/9781009157896.001

IPCC (2022): *Summary for Policymakers*. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie,

R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.001IUCN (2022) *Environment and Gender Information*. Available at: https://genderandenvironment.org/egi/

IUCN (2021) Forests and Climate Change, IUCN Issue Briefs

IUCN (2022a) *Environment and Gender Information*. Available at: https://genderandenvironment.org/egi/

IUCN (2022b) *New data reveals slow progress in achieving gender equality in environmental decision making*. Available at: https://www.iucn.org/news/gender/202103/new-data-reveals-slow-progress-achieving-gender-equality-environmental-decision-making

Jayasinghe G. and D.S.H.K. Ranasinghe (2008) "Carbon sequestration potential of Eucalyptus grandis and E. robusta in Nuwara Eliya and Badulla Forest Divisions of Sri Lanka", Annual Sessions of the SLAAS, 2008.

Jayasinghe, S. and Ranasinghe, H. (2009) "Investigation into the optimal nutrient regime for Swietenia macrophylla plantations in the wet zone of Sri Lanka", Proceedings of the 14th International Forestry and Environment Symposium, Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Proceedings of the 50th Anniversary Academic Conference, University of Sri Jayewardenepura.

Jayathilake, N., Kumara, I.U. and Fernando, S. (2020) 'Solid and Liquid Waste Management and Resource Recovery in Sri Lanka : A 20 City Analysis', *CGIAR Research Program on Water, Land and Ecosystems, International Water Management Institute*, pp. 1–83.

JICA (2014) ComTrans Transport Plan for Western Province. Available at: https://www.transport.gov.lk/web/images/downloads/F-CoMTrans_Main_S.pdf

Joseph, R., and Gunaratne, M.D.N., 2021, October. Optimization Of Vehicle Routing For Waste Collection And Transportation In The Ratmalana Area In Sri Lanka. In The 16th International Research Conference on Management and Finance (IRCMF–2021) (p. 496).

Karl and Tubiello (2021) 'FAO Statistics Working Paper Series, (21).

Klages, S. *et al.* (2018) 'FAIRWAY REPORT series Review report of Agri- Drinking Water quality source', (727984).

Knoema World Data Atlas *Sri Lanka Nitrous Oxide Emissions, 1960-2021 Knoema*. https://knoema.com/atlas/Sri-Lanka/topics/Environment/Emissions/Nitrous-oxide-emissions

Kuruppuarachchi, K.A.J.M., Madurapperuma, B.D., & Seneviratne, G. (2018). *Ecosystem Carbon Sequestration of Different Land-uses of the Lowland Wet Zone: A Case Study from Waga Area, Kalutara District, Sri Lanka.* 2nd International Research Symposium, Uva Wellassa University, Badulla, Sri Lanka.

Lawal, I.M. (2019) “Impact of population growth on Carbon Dioxide (CO2) emission: empirical evidence from Nigeria,” *Jurnal Perspektif Pembiayaan Dan Pembangunan Daerah*, 6(6), pp. 701–708. Available at: https://doi.org/10.22437/ppd.v6i6.6730.

Lee, C.T., Hashim, H., Ho, C. H., Fan, Y. V. and Klemeš, J. J. (2017) “Sustaining the low-carbon emission development in Asia and beyond: Sustainable energy, water, transportation and low-carbon emission technology,” *Journal of Cleaner Production*, 146, pp. 1–13. Available at: https://doi.org/10.1016/j.jclepro.2016.11.144.

Li, S., Deng, H. and Zhang, K. (2019) “The Impact of Economy on Carbon Emissions: An Empirical Study Based on the Synergistic Effect of Gender Factors,” *International Journal of Environmental Research and Public Health*, 16(19). Available at: https://doi.org/10.3390/ijerph16193723.

Liao, L., Luo, L., and Tang, Q. (2015) “Gender diversity, board independence, environmental committee and greenhouse gas disclosure,” *The British Accounting Review*, 47(4), pp. 409–424. Available at: https://doi.org/10.1016/j.bar.2014.01.002.

Listowski, A. *et al.* (2011) ‘Greenhouse Gas (GHG) Emissions from Urban Wastewater System : Future Assessment Framework and Methodology’, 1(1), pp. 113–125.

Liu, Y. *et al.* (2021) ‘Variations of GHG emission patterns from waste disposal processes in megacity Shanghai from 2005 to 2015’, *Journal of Cleaner Production*, 295, p. 126338.

Lou, X.F. and Nair, J. (2009) ‘The impact of landfilling and composting on greenhouse gas emissions - A review’, Bioresource Technology, 100(16), pp. 3792–3798. Available at: https://doi.org/10.1016/j.biortech.2008.12.006.

LUPPD of the Ministry of Lands and Land Development (2020) Data and information of home gardens in Sri Lanka.

Mahaweli Authority of Sri Lanka (2019) Corporate Plan 2019-2023

Marambe, Y.H.B., Ranasinghe, D.M.S.H.K. and Wahala, S. (2019) Estimating the biomass and carbon stocks in dominant tree species in wet zone home gardens of Sri Lanka, Proceedings of the 24th International Forestry and Environment Symposium, 11-12 October, 2019, Negombo

Marambe, Y.H.B., Ranasinghe, D.M.S.H.K. and Wahala, S. (2019) Estimating the biomass and carbon stocks in dominant tree species in wet zone home gardens of Sri Lanka, Proceedings of the 24th International Forestry and Environment Symposium, 11-12 October, 2019, Negombo

Marambe, B., & Nissanka, S.P. (2019). *Sri Lanka Status Report on Sustainable Nitrogen Management*. Ministry of Mahaweli Development and Environment, Sri Lanka. https://www.researchgate.net/publication/340915363_Sri_Lanka_Status_Report_on_Sustainable_Nitrogen_Management

Maria, C., Góis, J. and Leitão, A. (2020) ‘Challenges and perspectives of greenhouse gases emissions from municipal solid waste management in Angola’, *Energy Reports*, 6(xxxx), pp. 364–369. Available at: https://doi.org/10.1016/j.egyr.2019.08.074.

Massoud, M. (2001) 'Methane emissions from wastewater management', 114.

Mattsson, E., Ostwald, M., Nissanka, S.P. and Persson, U.M. (2012) REDD+ readiness implications for Sri Lanka in terms of reducing deforestation, Journal of Environmental Management 100: 29-40

Mattsson, E., Ostwald, M., Nissanka, S. P., & Marambe, B. (2013). Homegardens as a multi-functional land-use strategy in Sri Lanka with focus on carbon sequestration. *AMBIO*, *42*(7), 892–902. https://doi.org/10.1007/s13280-013-0390-x

Mattsson, E. Ostwala, M, Nissanka, S.P. and Pushpakumara, D.K.N.G. (2015) Quantification of carbon stock and tree diversity of homegardens in a dry zone area of Moneragala District, Sri Lanka, Agroforestry Systems, (89), 3, 435-445.

Mies, M. and Shiva, V. (1993) *Ecofeminism*, London: Zed Books.

Milazzo A., Goldstein M. (2017). Governance and Women's Economic and Political Participation: Power Inequalities, Formal Constraints and Norms. World Development Report 2017 Background Paper. World Bank, Washington, DC https://openknowledge.worldbank.org/bitstream/handle/10986/27267/116405_WDR17_BP_Governance_and_Womens_Participation-Milazzo_Goldstein.pdf?sequence=4&isAllowed=y

Ministry of Agriculture (2021) *National Agriculture Policy 2021 (NAP)*. Available at: https://www.agrimin.gov.lk/web/index.php/downloads/policy?lang=en

Ministry of Economic policies and Plan Implementation (2021) *National Accounts Estimates of Sri Lanka; 2 nd Quarter – 2021*, *Department of Census and Statistics*. Available at: http://www.statistics.gov.lk/qlink/pressrelease

Ministry of Environment & Renewable Energy and Ministry of Water Supply & Drainage (2009) 'Policy on siting of high polluting industries.

Ministry of Environment and Natural Resources (2003) *NATIONAL ENVIRONMENTAL POLICY AND STRATEGIES*, *Ministry of Environment*. Colombo, Sri Lanka: Ministry of Environment and Natural Resources. Available at: http://www.env.gov.lk/web/images/downloads/policies/national_environmental_policy_2003.pdf

Ministry of Forestry and Environment. (1995). *Sri Lanka Forestry Sector Master Plan*. Forestry Planning Unit, Ministry of Forestry and Environment, Battaramulla, Sri Lanka, 511 pp

Ministry of Healthcare & Nutrition & Ministry of Environment (2007) 'National Policy and strategy on cleaner production for the health sector.

Ministry of Land and Land Development "Mihikatha Medura", Land Secretariat 1200/6, Rajamalwatta Avenue, Battaramu October 2014

Ministry of Mahaweli Development and Environment Sri Lanka (2016) Nationally Determined Contributions

Ministry of Mahaweli Development and Environment Sri Lanka (2016) Readiness Plan for Implementation of Intended Nationally Determined Contributions (INDCs) 2017-2019

Ministry of Plantations, the areas available for planting, personnel communication

Minister of Power, Energy and Business Development (2019) *National Energy Policy and Strategies of Sri Lanka*, Gazette No. 2135/61 - Friday, August 09, 2019, https://www.energy.gov.lk/images/resources/downloads/national-energy-policy-2019-en.pdf

Ministry of Women and Child Affairs (2016) *Cabinet Memorandum No.: MWCA/CM/2016/11*. Colombo, Sri Lanka: Ministry of Women and child Affairs. Available at: https://www.dropbox.com/s/41ihbiwnu1njida/establishment%20of%20mainstreaming.pdf?dl=0

MoE (2000) Initial National Communication under the United Nations Framework Convention on Climate Change Available at: https://unfccc.int/resource/docs/natc/srinc1.pdf

MoE (2011) *Second National Communication on Climate Change* ISBN: 978-955-0033-22-5 Available at: https://unfccc.int/resource/docs/natc/lkanc2.pdf

(MoE, 2014) The National Climate Change Policy of Sri Lanka Available at: http://www.climatechange.lk/CCS%20Policy/Climate_Change_Policy_English.pdf

MoE (2019) *National Policy on Waste Management*.

MoE (2021a) *Updated Nationally Determined Contributions under the Paris Agreement on Climate Change Sri Lanka*, Ministry of Environment, Sri Lanka Available at: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Syrian Arabic Republic First/FirstNDC-Eng-Syrian Arab Republic.pdf.

MoE (2021b) Low Carbon Development Strategy for Sri Lanka 2021-2030, Draft

MoE (2021c) Draft Third National Communication

MoE (2021d) *National Action Plan on Plastic Waste Management 2021-2030*.

MoE (2022a) Third National Communication of Climate Change in Sri Lanka ISBN: 978-624-5817-25-2

MoE (2022b) National Environmental Action Plan 2022-2030: *Pathway to Sustainable Development*. Colombo, Sri Lanka: Ministry of Environment. Available at: http://www.env.gov.lk/web/images/downloads/policies/NEAP_2022.pdf

Munasinghe, E. S., Rodrigo, V. H., & Karunathilake, P. K. (2011). Carbon sequestration in mature rubber (*hevea brasiliensis* muell. arg.) plantations with genotypic comparison. *Journal of the Rubber Research Institute of Sri Lanka*, *91*, 36–48. https://doi.org/10.4038/jrrisl.v91i0.1851

Myers, N., Russell, A., Mittermeier, C., Mittermeier, G., Da Fonseca, G.A.B. and Kent, J. (2000), Biodiversity hotspots for conservation priorities, Nature 403, 853-858

National Communication (Natcom) (2000). Democratic Socialist Republic of Sri Lanka. Initial National Communication under the United Nations Framework Convention on Climate Change.

NRDC (2022) *Greenhouse effect 101*, Available at: https://www.nrdc.org/stories/greenhouse-effect-101#gases

NTC (2021). *Transport Statistics* Available at: https://www.ntc.gov.lk/corporate/pdf/2022/statistics_Report/Stat_2021_EN.pdf

Nuber, C. and Velte, P. (2021) "Board gender diversity and carbon emissions: European evidence on curvilinear relationships and critical mass," *Business Strategy and the Environment*, 30(4), pp. 1958–1992. Available at: https://doi.org/10.1002/bse.2727.

Ourworldindata.org (n.d.). *CO2 emissions by sector*. Our World in Data. https://ourworldindata.org/grapher/co-emissions-by-sector?country=%7ELKA

Overview, World Bank Web. Available at: https://www.worldbank.org/en/country/srilanka/overview

Pan, T., Zhu, X.D. and Ye, Y.P., 2011. Estimate of life-cycle greenhouse gas emissions from a vertical subsurface flow constructed wetland and conventional wastewater treatment plants: A case study in China. Ecological Engineering, 37(2), pp.248-254.

Pathinayake, P. Kumarathunga, M and Nissanka, S (2012) Aboveground tree carbons tocks of lowland evergreen mixed vegetation at Gannoruwa. Proceedings of the International Forestry and Environmental Symposium, University of Sri Jayewardenepura, Sri Lanka

Peiris, T.S.G. and Kularatne, J.D.J.S. (2022) Statuas of coconut paoms in Sri Lanka, Daily News On Line

Perera, K.A.R.S., De Silva, K.H.W.L. and Amarasinghe, M.D. (2017) Potential impact of predicted sea level rise on carbon sink function of mangrove ecosystems with special reference to Negombo estuary, Sri Lanka, Global and Planetary Change, Elsevier Science 0921-8181

Perera, S. & Ranasinghe, D.M.S.H.K. (2013) "Carbon sequestration potential of privately managed Swietenia macrophylla plantations in the Wet and Intermediate Zones of Sri Lanka", Proceedings of the International Forestry and Environment Symposium, University of Sri Jayewardenepura, 2013.

Perera, S. & Ranasinghe, D.M.S.H.K. (2013) "Carbon sequestration potential of privately managed Swietenia macrophylla plantations in the Wet and Intermediate Zones of Sri Lanka", Proceedings of the International Forestry and Environment Symposium, University of Sri Jayewardenepura, 2013.

Pilli, S. *et al.* (2016) 'Fenton pre-treatment of secondary sludge to enhance anaerobic digestion: Energy balance and greenhouse gas emissions, *Chemical Engineering Journal*, 283, pp. 285–292. Available at: https://doi.org/10.1016/j.cej.2015.07.056.

Pimonenko, T., Lyulyov, O., Chygryn, O., & Palienko, M. (2018). Environmental Performance Index: relation between social and economic welfare of the countries. *Environmental Economics*, *9*(3), 1–11. https://doi.org/10.21511/ee.09(3).2018.01

Proceedings of the 6th International conference on Multidisciplinary Approaches, Faculty of Graduate Studies, University of Sri Jayewardenepura, November 26 Colombo.

Proceedings of the 26th International Forestry and Environment Symposium, 20-21 January, 2022, Nugegoda, Sri Lanka.

Pushpakumara, DKNG, Marambe, B., Silva, G.L.L.P., Weerahewa, J. and Punyawardena, V.R. (2012), A Review of research on homegardens in Sri Lanka: The status, importance and future perspective, Tropical Agriculturist, Vol. 160.

Punyawardena, BVR. (2007) Agro-ecology (Map and Accompanying Text). National Atlas of Sri Lanka. 2nd ed. Colombo: Survey Department.

Rajaeifar, M.A. *et al.* (2017) 'Electricity generation and GHG emission reduction potentials through different municipal solid waste management technologies: A comparative review', *Renewable and Sustainable Energy Reviews*, 79(April), pp. 414–439. Available at: https://doi.org/10.1016/j.rser.2017.04.109.

Ranasinghe, C.S. and Thimothias, K.S.H. (2012) Estimation of carbon sequestration potential in coconut plantations under different agro-ecological regions and land suitability classes, Journal of National Science Foundation, Sri Lanka 40 (1): 77-93

Ranasinghe, D.M.S.H.K. (2019) The potential of forests as an overall sustainable carbon sink

Ranasinghe, H. (2022) The importance of forestry in the pledge of arriving at carbon neutrality in Sri Lanka, Proceedings of the 26th International Forestry and Environment Symposium, 20-21 January, 2022, Nugegoda, Sri Lanka.

Ranasinghe, C. S., & Thimothias, K. S. (2012). Estimation of carbon sequestration potential in coconut plantations under different agro-ecological regions and land suitability classes. *Journal of the National Science Foundation of Sri Lanka*, *40*(1), 77–93. https://doi.org/10.4038/jnsfsr.v40i1.4171

RDA (2020) *National Highways*. Available at: http://www.rda.gov.lk/source/rda_roads.htm

RDA (2021) *National Highway Master Plan 2021-2030*, Road Development Authority, Sri Lanka

Ross, K., Hite, K., Waite, R., Carter, R., Pegorsch, L., Damassa, T., and Gasper,R. (2019). Enhancing NDCs:
Opportunities In Agriculture, Working Paper, World Resources Institute.

Roupsard, O., Lamanda, N., Jourdan, C., Navarro , M. N. V., Mialet-Serra, I., Dauzat, J., & Sileye, T. (2008). Coconut carbon sequestration part 1 / highlights on carbon cycle in coconut plantations. *CORD*, *24*(1), 14. https://doi.org/10.37833/cord.v24i1.155

Samarakoon, M.B., Suresh, K.A.S. and Amarawardana, D. (2016) 'Reducing the Volume of Municipal Solid Waste in Karadiyana Dumpsite by Using Compaction Method', pp. 90–95.

Senarathne, S., Ranasinghe, DMSHK and Wahala, WMPSB (2022) Assessment of Biodiversity and Blue Carbon in Mangroves, Sea grasses, Salt Marshes and Algae in Mannar: Northern Sri Lanka, Senevirathne, U., Ranasinghe, D.M.S.H.K. and Wahala, S. (2013) "Estimation of Aboveground Carbon Stocks in Selected Home gardens in 4 Agro Ecological Regions in the Intermediate Low Country of Sri Lanka", Proceedings of the International Forestry and Environment Symposium, University of Sri Jayewardenepura, 2013.

Shiva, V. (1988). *Staying Alive: Women, Ecology and Development*, London: Zed Books

Skillicorn, D.B., Zheng, Q. and Morselli, C. (2013) 'Waste and Climate Change', *Proceedings of the 2013 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining, ASONAM 2013*, pp. 316–323. Available at: https://doi.org/10.1145/2492517.2492522.

SLSEA *Energy Balance Yearbook (Data from 1983 to 2019)*

SLSEA (2016) *Disaggregation of Petroleum Product Usage by End-Use Category*, Sri Lanka Sustainable Energy Authority

SLSEA (2019) Sri Lanka Energy Balance 2019 Available at: https://www.energy.gov.lk/images/energy-balance/energy-balance-2019-lq.pdf

SLSEA (2019) Sri Lanka Energy Balance 2019 Available at: https://www.energy.gov.lk/images/energy-balance/energy-balance-2019-lq.pdf

Somasiri, L.L.W., Nadarajah, N., Amarasinghe, L., & Gunathilake, H.A.J. (1994). *Land suitability assessment of coconut growing area in the coconut triangle*. Occasional Publication Series, Coconut Research Institute, Sri Lanka.

Sri Lanka CO2 emissions from transport, 1970-2022 - knoema.com. (2022). Knoema. https://knoema.com/atlas/Sri-Lanka/topics/Transportation/CO2-Emissions-from-transport/CO2-emissions-from-transport

Sri Lanka Mangrove Conservation Project (2018), UNFCCC

Srivastava, V. *et al.* (2016) 'Biological response of using municipal solid waste compost in agriculture as fertilizer supplement', *Reviews in Environmental Science and Bio/Technology* [Preprint]. Available at: https://doi.org/10.1007/s11157-016-9407-9.

Sugathapala, K.C. and Jayathilake, K.A.D.S.B. (2012) A green area ratio for Sri Lankan urban areas, Proceeding of the NBRO Symposium on Sustainable Disaster Resilient Technologies (2012)At: Colombo, Sri Lanka

Sustainable Agriculture Research and Education. (2012). *Capture Fuel from Animal Manure and Plant Waste.* https://www.sare.org/wp-content/uploads/Clean-Energy-Farming.pdf

Tian, L., Zhang, Y. and Zhu, J. (2014) "Decreased surface albedo driven by denser vegetation on the Tibetan Plateau," *Environmental Research Letters*, 9(10), p. 104001. Available at: https://doi.org/10.1088/1748-9326/9/10/104001

Uddin, M.Md.M. (2014) "Causal Relationship between Education, Carbon Dioxide (CO2) Emission and Economic Growth in Bangladesh," *IOSR Journal of Humanities and Social Science*, 19(4), pp. 60–67. Available at: https://doi.org/10.9790/0837-19486067.

UN (2022) *World Population Prospects* Department of Economic and Social Affairs Population Division Available at: https://population.un.org/wpp/Download/Standard/Population/

UNEP (2018) *Gender and Environment, Empowering Rural Women: A Policy Brief, UNEP*. Available at: https://wedocs.unep.org/bitstream/handle/20.500.11822/25185/sdG_Brief_002_gender.pdf?sequence=1&isAllowed=y

UNEP (2020) *GOAL 5: Gender equality*. Available at: https://www.unep.org/explore-topics/sustainable-development-goals/why-do-sustainable-development-goals-matter/goal-5

UNEP (2020) *GOAL 10: Reduced inequalities*. Available at: https://www.unep.org/explore-topics/sustainable-development-goals/why-do-sustainable-development-goals-matter/goal-10

UNEP (2021) Emissions Gap Report 2021: The Heat is On

UNEP (2022) Emissions Gap Report

UNFCCC (2000) Initial National Communication under the United Nations Framework Convention on Climate Change, Sri Lanka, Available at: https://unfccc.int/resource/docs/natc/srinc1.pdf

UNFCCC (2016) *The Paris Agreement*. UNFCCC. Available at: https://unfccc.int/sites/default/files/resource/parisagreement_publication.pdf

UNFCCC (no date) *National Gender & Climate Change Focal Points*. Available at: https://unfccc.int/topics/gender/resources/list-of-gender-focal-points-under-the-unfccc

United Nations Environment Programme (2022). *Emissions Gap Report 2022*: The Closing Window — Climate crisis calls for rapid transformation of societies. Nairobi. Available at: https://www.unep.org/emissions-gap-report-2022

UN Women (2020) *Country Fact Sheet | UN Women Data Hub*. Available at: https://data.unwomen.org/country/sri-lanka

V20 (2022) *SRI LANKA CLIMATE PROSPERITY PLAN* Available at: https://www.v-20.org/resources/publications/sri-lanka-climate-prosperity-plan

Vahk, J. (2020) 'Landfill emission reductions only tell half the story as GHG emissions from waste-to-energy incineration double'. Available at: https://zerowasteeurope.eu/library/landfill-emission-reductions-only-tell-half-the-story-as-ghg-emissions-from-waste-to-energy-incineration-double/

Vasilakos, C., Tsekouras, G. E., & Kavroudakis, D. (2022). LSTM-Based Prediction of Mediterranean Vegetation Dynamics Using NDVI Time-Series Data. *Land*, *11*(6), 923. https://doi.org/10.3390/land11060923

Wahala, W. M.P.S.B. , Ranasinghe, DMSHK and Amaraskera, H.S. (2013) Determination of the biomass production and carbon sequestration capacity of wet zone forests in Sri Lanka, PhD Thesis, University of Sri Jayewardenepura

Wahala, W.M.P.S.B., Ratnayake, R.M.D.D. and Ranasinghe, D.M.S.H.K. (2006) "Mitigating the impacts of climate change – Carbon sequestration capacity of selected natural forests in the humic zones of Sri Lanka", Proceedings of the International Conference on Humid Tropical Ecosystems: Changes, Challenges, Opportunities, 4-9 December, 2006, Kandy, Sri Lanka.

Wahala, W.M.P.S.B., Ratnayake, R.M.D.D. and Ranasinghe, D.M.S.H.K. (2006) "Mitigating the impacts of climate change – Carbon sequestration capacity of selected natural forests in the humic zones of Sri Lanka", Proceedings of the International Conference on Humid Tropical Ecosystems: Changes, Challenges, Opportunities, 4-9 December, 2006, Kandy, Sri Lanka.

Wang, Fang *et al.* (2021) 'Technologies and perspectives for achieving carbon neutrality', *The Innovation*, 2(4). Available at: https://doi.org/10.1016/j.xinn.2021.100180.

Wang, C., Cardon, P.W., Liu, J., Madni, G.R., and Xue, B. (2020) "Social and economic factors responsible for environmental performance: A global analysis," *PLOS ONE*. Edited by B. Xue, 15(8). Available at: https://doi.org/10.1371/journal.pone.0237597.

Weerawardana, WPTD et al., 2013, COCOS 2013 20

Wichelns, D. (2016) "Managing water and soils to achieve adaptation and reduce methane emissions and arsenic contamination in Asian rice production," *Water*, 8(4), p. 141. Available at: https://doi.org/10.3390/w8040141.

Wijekoon, P. *et al.* (2020) 'Biomass valorization and phytoremediation as integrated Technology for Municipal Solid Waste Management for developing economic context'

Wijeratne, T.L., De Costa, W.A.J.M. and Wijeratne, M.A. , Carbon Sequestration Potential of Tea Plantations in Sri Lanka, a presentation to the Tea Research Institute, Sri Lanka

WOW (2021). *Women and the Net Zero economy: A briefing on changes in garment, agriculture and energy supply chains*, USAID: Work and Opportunities for Women

World Bank and CIAT. (2015). *Climate-smart agriculture in Sri Lanka. CSA country profiles for Africa, Asia, and Latin America and the Caribbean series*. Washington D.C., The World Bank Group. http://dx.doi.org/10.13140/RG.2.2.24151.37283

World Bank *Nitrous oxide emissions (% change from 1990) - sri lanka Data*. Available at: https://data.worldbank.org/indicator/EN.ATM.NOXE.ZG?locations=LK

World Bank Group (1975) *Sri Lanka - Agricultural policy and program review (English).* Washington, D.C. : World Bank Group. Available at: http://documents.worldbank.org/curated/en/860331468104352096/Sri-Lanka-Agricultural-policy-and-program-review

Xi, J. *et al.* (2021) 'Science of the Total Environment The evaluation of GHG emissions from Shanghai municipal wastewater treatment plants based on IPCC and operational data integrated methods (ODIM)', *Science of the Total Environment*, 797, p. 148967. Available at: https://doi.org/10.1016/j.scitotenv.2021.148967.

Xing, Z. *et al.* (2012) 'Greenhouse Gas Emissions from Sewage Treatment in China during 2000 – 2009', *Advances in Climate Change Research*, 3(4), pp. 205–211. Available at: https://doi.org/10.3724/SP.J.1248.2012.00205.

Xu, F. and Mayuga, K. (2022) From crisis to opportunity: How the Philippines built 500km of bike lanes in less than a year Available at: https://blogs.worldbank.org/transport/crisis-opportunity-how-philippines-built-500km-bike-lanes-less-year

Yin, Z., Jiang, X., Lin, S. and Liu, J. (2022) “The impact of online education on carbon emissions in the context of the COVID-19 pandemic – Taking Chinese universities as examples,” *Applied Energy*, 314. Available at: https://doi.org/10.1016/j.apenergy.2022.118875.

Zaini IN, Rueda YG, López CristinaGarcí, Ratnasari DK, Helsen L, Pretz T, Jönsson PäGö, Yang W, Production of H2-rich syngas from excavated landfill waste through steam Cogasification with biochar, Energy (2020), doi: https://doi.org/10.1016/j.energy.2020.118208.

Zeng, L. *et al.* (2014) ‘Greenhouse gases emissions from solid waste: an analysis of Expo 2010 Shanghai, China, *Journal of Material Cycles and Waste Management*, 16(4), pp. 616–622. Available at: https://doi.org/10.1007/s10163-014-0280-8.

Zhang, C. *et al.* (2022) ‘An overview of the waste hierarchy framework for analyzing the circularity in construction and demolition waste management in Europe’, *Science of the Total Environment*, 803, p. 149892. Available at: https://doi.org/10.1016/j.scitotenv.2021.149892.

ANNEXURES

ANNEXURE 1: WORKSHOP AGENDA LIST (23.09.2023)

ANNEXURE 2: LIST OF PARTICIPANTS FOR THE SECOND WORKSHOP – 18.11.2023

ANNEXURE 3: AGENDA OF THE WORKSHOP

Ministry of Environment

UNDP

EML Consultants

WORKSHOP- TO DEVELOP A 2050 CARBON NET ZERO ROAD MAP AND STRATEGIC PLAN FOR SRI LANKA-AGENDA

Date: 23.09.2022

Time: 9.00 am – 2.30 pm

Venue: Nelum, Water's Edge, Battaramulla

Time	Description
9.00 am - 9.30 am	Registration and Tea
9.30 am - 9.40 am	Welcome address by the Secretary, Ministry of Environment
9.40 am -9.45 am	Remarks by UNDP
9.45 am -9.50 am	The objective of the Workshop by the Director, Climate Change Secretariat, Ministry of Environment
9.50 am -10.00 am	Self-introduction of the team
10.00 am -10.30 am	Introduction to the stakeholders on the outline of the project, theconcepts, the method of work
10.30 am -11.00 am	Refreshment Break and Breaking out into the sector groups
11.00 am -1.30 am	Breakout sessions – led by the sector consultants
1.30 am -1.45 am	Closing session (plenary) followed by lunch

ANNEXURE 4: AGENDA OF THE WORKSHOP

WORKSHOP- TO DEVELOP A 2050 CARBON NET ZERO ROAD MAP AND STRATEGIC PLAN FOR SRI LANKA-AGENDA

Date: 18/ 11/ 2022

Time: 9.00 am – 2.30 pm

Venue: Nelum Hall, Water's Edge, Battaramulla

Agenda

Time	Item
9.00 am – 9.30 am	Registration of Participants
9.30 am - 10.00 am	Welcome Address – Team Leader, Prof. Niranjanie Ratnayake
10.15 am – 1.40 pm Breakout Sessions	
	Breakout sessions for each sector, chaired by the sector specialist, andsupported by the RA's: • Energy - Dr. Asanka Rodrigo • Transport - Dr. Loshaka and Dr Pasindu • Industry – Mr. Nimal • Waste – Prof. Bandunee • Agriculture – Dr. Dharmasena • Forestry sector: to be chaired by Dr. Dharmasena jointly with Agriculture Sector as Prof. Hemanthi will be overseas. • Economic – Prof. Prashanthi • Social and Gender – Prof Subhangi
10.15 am – 10.45 am	Introductory presentation by the sector expert – Energy, Transport, Waste, Industry, Agriculture and Forestry sector experts please prepare slides to show the following: ➢ Identification of the baseline scenario: Let us take NDC scenario with only unconditional actions as the baseline ➢ Calculated emission predictions in the baseline scenario (With graphs showing the predictions up to 2050) ➢ Considered scenarios and drivers which are used in the scenario development

	➢ Mathematical model used for the predictions up to 2050 ➢ Proposed mitigatory actions with timeline to bring down the emissions and increase storage/sequestration according to your plan ➢ Gaps found in the first stakeholder workshop ✓ Policy/ Strategy ✓ Staff ✓ Technology ✓ Infrastructure
10.45 am – 11.15 am	**Tea Break**
Within the breakout rooms	
11.15 am – 12.00 noon	Discussion of the feasibility of the proposed actions and the timeline according to the stakeholders' opinions
12.00 noon -12.20 pm	New actions and timelines proposed by the stakeholders
12.20 pm – 12.40 pm	Available regulatory framework for the implementation of proposed actions and any gaps
12.40 pm – 1.00 pm	Identify institutional arrangements and new policies/ amendments to policies needed for the implementation of actions, strengths and weaknesses in the system and opportunities for improvement
1.00 pm – 1.20 pm	SWOT analysis
1.20 pm 1.40 pm	Presentation of the outcome of the discussion by the Sectoral Leaders
1.40 pm to 1.45 pm	Vote of Thanks
Lunch	
End of Workshop	

ANNEXURE 5: Proposed Strategies and action plans in Energy Sector

Table 1: Proposed Strategies and action plans in Energy Sector

YEAR	RENEWABLE CAPACITY & GRID-SCALE ENERGY STORAGE CAPACITY ADDITIONS AND RETIREMENTS	THERMAL CAPACITY ADDITIONS and RETIREMENTS
2022	**Uma Oya Hydropower Plant 120 MW** Distribution Connected Embedded Solar 160 MW **Grid Connected Partially Facilitated Solar 94 MW** Mini Hydro 20 MW Biomass 10 MW	
2023	Distribution Connected Embedded Solar 160 MW **Grid Connected Partially Facilitated Solar 1 147 MW** **Wind 25 MW** Mini Hydro 20 MW Biomass 20 MW	**Gas Turbine of Sobadhanvi NG Combined Cycle Plant (Kerawalapitiya) 235 MW** Short-Term Supplementary Power 2 320 MW Combined Cycle Power Plant (KPS–2) 163 MW *Retirement of* *Sojitz Kelanitissa Combined Cycle Plant 3* (163) MW
2024	Moragolla **Hydropower Plant 31 MW** Distribution Connected Embedded Solar 160 MW Grid Connected Partially Facilitated Solar 1 223 MW Grid Connected Fully Facilitated Solar 100 MW **Wind 60 MW** Mini Hydro 20 MW Biomass 20 MW Standalone Battery Energy Storage 20 MW/50 MWh	**New Gas Turbines – Kelanitissa 4 130 MW** **Steam Turbine of Sobadhanvi NG Combined Cycle Plant (Kerawalapitiya) 115 MW** **Gas Turbine of Second NG Combined Cycle Plant (Kerawalapitiya) 235 MW** *Retirement of* *Kelanitissa Gas Turbines 5 (68) MW* *Short-Term Supplementary Power (200) MW*
2025	Distribution Connected Embedded Solar 165 MW Grid Connected Partially Facilitated Solar 80 MW Grid Connected Fully Facilitated Solar 260 MW (With Battery Energy Storage) 100 MW/400 MWh Wind (Mannar)6 100 MW Wind 100 MW Mini Hydro 25 MW Biomass 20 MW	**Steam Turbine of Second NG Combined Cycle Plant (Kerawalapitiya**) **115 MW** *Retirement of* *CEB Barge Power Plant 7 (62) MW*
2026	Distribution Connected Embedded Solar 170 MW Grid Connected Partially Facilitated Solar 70 MW Grid Connected Fully Facilitated Solar 260 MW (With Battery Energy Storage) 100 MW/400 MWh Wind 290 MW Mini Hydro 25 MW Biomass 20 MW Standalone Battery Energy Storage 80 MW/320 MWh	IC Engine Power Plant -Natural Gas (Western Region) 200 MW *Retirement of* *Gas Turbine (GT7)8 (115) MW* *4x17 MW Sapugaskande Diesel 8x9 MW (68) MW* *Sapugaskande Diesel Ext Short Term (72) MW* *Supplementary Power (120) MW*
2027	Distribution Connected Embedded Solar 170 MW Grid Connected Partially Facilitated Solar 50 MW Grid Connected Fully Facilitated Solar 280 MW (With Battery Energy Storage) 100 MW/400MWh	Gas Turbine -Natural Gas (Western Region) 100 MW

YEAR	RENEWABLE CAPACITY & GRID-SCALE ENERGY STORAGE CAPACITY ADDITIONS AND RETIREMENTS		THERMAL CAPACITY ADDITIONS and RETIREMENTS	
	Wind Mini Hydro Biomass Standalone Battery Energy Storage MW/400 MWh	250 MW 25 MW 20 MW 100		
2028	Distribution Connected Embedded Solar Grid Connected Partially Facilitated Solar Grid Connected Fully Facilitated Solar (With Battery Energy Storage) Wind Mini Hydro Biomass Standalone Battery Energy Storage MWh	170 MW 40 MW 310 MW 150 MW/600 MWh 200 MW 25 MW 20 MW 200MW/800		
2029	Distribution Connected Embedded Solar Grid Connected Partially Facilitated Solar Grid Connected Fully Facilitated Solar (With Battery Energy Storage) Wind Mini Hydro Biomass Pumped Storage Hydropower	170 MW 20 MW 350 MW 150 MW/600 MWh 250 MW 25 MW 20 MW 350 MW		
2030	Distribution Connected Embedded Solar Grid Connected Partially Facilitated Solar Grid Connected Fully Facilitated Solar (With Battery Energy Storage) Wind Mini Hydro Biomass Pumped Storage Hydropower	170 MW 30 MW 250 MW 125 MW/500MWh 200 MW 10 MW 20 MW 350 MW		
2031	Distribution Connected Embedded Solar Grid Connected Partially Facilitated Solar Grid Connected Fully Facilitated Solar (With Battery Energy Storage) Wind Mini Hydro Biomass Pumped Storage Hydropower	170 MW 30 MW 250 MW 125 MW/500MWh 200 MW 10 MW 20 MW 350 MW	-	
2032	Distribution Connected Embedded Solar Grid Connected Partially Facilitated Solar Grid Connected Fully Facilitated Solar (With Battery Energy Storage) Wind Mini Hydro Biomass Pumped Storage Hydropower	170 MW 30 MW 250 MW 125 MW/500MWh 150 MW 10 MW 20 MW 350 MW		
	Distribution Connected Embedded Solar Grid Connected Partially Facilitated Solar Grid Connected Fully Facilitated Solar (With Battery Energy Storage) Wind	170 MW 30 MW 300 MW	Gas Turbine -Natural Gas *Retirement of* *Gas Turbine of Sobadhanvi NG Combined Cycle Plant (Kerawalapitiya)*	150 MW *(235) MW*

YEAR	RENEWABLE CAPACITY & GRID-SCALE ENERGY STORAGE CAPACITY ADDITIONS AND RETIREMENTS		THERMAL CAPACITY ADDITIONS and RETIREMENTS	
2033	Mini Hydro Biomass	150 MW/600MWh 150 MW 10 MW 20 MW	*Combined Cycle Plant (KPS) Combined Cycle Plant (KPS- 2) Uthuru Janani Power Plant*	*(165) MW* *(163) MW* *(26.7) MW*
2034	Distribution Connected Embedded Solar Grid Connected Partially Facilitated Solar Grid Connected Fully Facilitated Solar (With Battery Energy Storage) Wind Mini Hydro Biomass	180 MW 30 MW 300 MW 150 MW/600MWh 150 MW 10 MW 20 MW	HVDC interconnection	500 MW
2035	Distribution Connected Embedded Solar Grid Connected Partially Facilitated Solar Grid Connected Fully Facilitated Solar (With Battery Energy Storage) Wind Mini Hydro Biomass Standalone Battery Energy Storage	180 MW 30 MW 300 MW 125MW/500MWh 150 MW 10 MW 10 MW 50MW/200MWh	Nuclear power Plant *Retirement of* *West Coast Combined Cycle Power Plant*	500 MW *(300) MW*
2036	Distribution Connected Embedded Solar Grid Connected Partially Facilitated Solar Grid Connected Fully Facilitated Solar (With Battery Energy Storage) Wind Mini Hydro Biomass Standalone Battery Energy Storage	190 MW 30 MW 300 MW 100MW/400MWh 150 MW 10 MW 10 MW 100MW /400MWh		
2037	Distribution Connected Embedded Solar Grid Connected Partially Facilitated Solar Grid Connected Fully Facilitated Solar (With Battery Energy Storage) Wind Mini Hydro Biomass Standalone Battery Energy Storage	190 MW 30 MW 300 MW 100MW/400MWh 150 MW 10 MW 10 MW 100MW/400MWh		
2038	Distribution Connected Embedded Solar Grid Connected Partially Facilitated Solar Grid Connected Fully Facilitated Solar (With Battery Energy Storage) Wind Mini Hydro Biomass Standalone Battery Energy Storage	200 MW 30 MW 300 MW 100MW/400MWh 150 MW 10 MW 10 MW 100MW/400MWh		
2039	Distribution Connected Embedded Solar Grid Connected Partially Facilitated Solar Grid Connected Fully Facilitated Solar (With Battery Energy Storage) Wind Mini Hydro Biomass Standalone Battery Energy Storage	200 MW 30 MW 300 MW 100 MW/400 MWh 150 MW 10 MW 10 MW 100 MW/400 MWh		

YEAR	RENEWABLE CAPACITY & GRID-SCALE ENERGY STORAGE CAPACITY ADDITIONS AND RETIREMENTS	THERMAL CAPACITY ADDITIONS and RETIREMENTS
2040	Distribution Connected Embedded Solar 220 MW Grid Connected Partially Facilitated Solar 20 MW Grid Connected Fully Facilitated Solar 310 MW (With Battery Energy Storage) 115 MW/460 MWh Wind 150 MW Biomass 10 MW Standalone Battery Energy Storage 100 MW/400 MWh	Nuclear Power Plant 1000 MW
2041	Distribution Connected Embedded Solar 220 MW Grid Connected Partially Facilitated Solar 20 MW Grid Connected Fully Facilitated Solar 310 MW (With Battery Energy Storage) 125 MW/500 MWh Wind 150 MW Biomass 20 MW Standalone Battery Energy Storage 100 MW/400 MWh	*Retirement of* *Lakvijaya Coal Power Plant Unit 1 (300) MW*
2042	Distribution Connected Embedded Solar 220 MW Grid Connected Partially Facilitated Solar 30 MW Grid Connected Fully Facilitated Solar 320 MW (With Battery Energy Storage) 125 MW/500 MWh Wind 200 MW Biomass 20 MW Standalone Battery Energy Storage 150 MW/600 MWh	
2043	Distribution Connected Embedded Solar 220 MW Grid Connected Partially Facilitated Solar 30 MW Grid Connected Fully Facilitated Solar 320 MW (With Battery Energy Storage) 125 MW/500 MWh Wind 200 MW Biomass 20 MW	
2044	Distribution Connected Embedded Solar 220 MW Grid Connected Partially Facilitated Solar 30 MW Grid Connected Fully Facilitated Solar 320 MW (With Battery Energy Storage) 125 MW/500 MWh Wind 200 MW Biomass 30 MW	*Retirement of* *Lakvijaya Coal Power Plant Unit 2 and 3 (600) MW*
2045	Distribution Connected Embedded Solar 220 MW Grid Connected Partially Facilitated Solar 30 MW Grid Connected Fully Facilitated Solar 320 MW (With Battery Energy Storage) 125 MW/500 MWh Wind 200 MW Biomass 30 MW	
2046	Distribution Connected Embedded Solar 230 MW Grid Connected Partially Facilitated Solar 30 MW Grid Connected Fully Facilitated Solar 330 MW (With Battery Energy Storage) 125 MW/500 MWh Wind 200 MW Biomass 30 MW	
2047	Distribution Connected Embedded Solar 230 MW Grid Connected Partially Facilitated Solar 30 MW Grid Connected Fully Facilitated Solar 330 MW (With Battery Energy Storage) 125 MW/500 MWh Wind 200 MW	HVDC interconnection 500 MW

YEAR	RENEWABLE CAPACITY & GRID-SCALE ENERGY STORAGE CAPACITY ADDITIONS AND RETIREMENTS	THERMAL CAPACITY ADDITIONS and RETIREMENTS
	Biomass 30 MW	
2048	Distribution Connected Embedded Solar 240 MW Grid Connected Partially Facilitated Solar 40 MW Grid Connected Fully Facilitated Solar Battery Energy Storage) 340 MW (With 125 MW/500 MWh Wind 200 MW Biomass 30 MW	
2049	Distribution Connected Embedded Solar 250 MW Grid Connected Partially Facilitated Solar 40 MW Grid Connected Fully Facilitated Solar Battery Energy Storage) 360 MW (With 125 MW/500 MWh Wind 300 MW Biomass 30 MW	*Retirement of* *New Gas Turbines – Kelanitissa 130 MW* *Steam Turbine of Sobadhanvi NG Combined-Cycle Plant (Kerawalapitiya) 115 MW* *Gas Turbine of Second NG Combined Cycle Plant (Kerawalapitiya) 235 MW* *Steam Turbine of Second NG Combined Cycle Plant (Kerawalapitiya) 115MW* *IC Engine Power Plant -Natural Gas (Western Region) 200MW*
2050	Distribution Connected Embedded Solar 270 MW Grid Connected Partially Facilitated Solar 50 MW Grid Connected Fully Facilitated Solar Battery Energy Storage) 380 MW (With 125 MW/500 MWh Wind 300 MW Biomass 30 MW	*Retirement of* *Gas Turbine -Natural Gas (Western Region) 100 MW*

ANNEXURE 6: Baseline and Mitigation Scenario Calculations of Forestry Sector

Table 1: The projected extents of forests, trees outside forests and mangroves (ha) from 2025-2050 in the Baseline Scenario

Year	Forest cover	New plantings	Total forest cover including existing and new plantings	Home gardens	Coconut plantations	Tea Plantations	Mixed trees with other perennials	Mangroves	Urban green cover and areas with avenue plants
2025	2043962	1805	2045767	892560	467593.8	326509	118000	17868.7323	7514.8
2026	2039067	1805	2040872	901485.6	467118.8	341509	118822.222	17690.0626	8014.8
2027	2034172	1805	2035977	910500.5	466643.8	356509	118822.222	17513.1795	8514.8
2028	2029277	1805	2031082	919605.5	466168.8	371509	119465.556	17338.0653	9014.8
2029	2024382	1805	2026187	928801.5	465693.8	386509	120108.889	17164.7023	9514.8
2030	2019487	1805	2021292	938089.6	465218.8	401509	118822.222	16993.0729	10014.8
2031	2014487	1805	2016292	947470.4	464743.8	416509	119465.556	16823.1597	10514.8
2032	2009487	1805	2011292	956945.2	464268.8	431509	120108.889	16654.9457	11014.8
2033	2004487	1805	2006292	966514.6	463793.8	446509	120752.222	16488.4139	11514.8
2034	1999487	1805	2001292	976179.7	463318.8	461509	121395.556	16323.5473	12014.8

Year	Forest cover	New plantings	Total forest cover including existing and new plantings	Home gardens	Coconut plantations	Tea Plantations	Mixed trees with other perennials	Mangroves	Urban green cover and areas with avenue plants
2035	1994487	1805	1996292	985941.5	462843.8	476509	122038.889	16160.3295	12514.8
2036	1989487	1805	1991292	995801	462368.8	491509	122682.222	15998.7438	13014.8
2037	1984487	1805	1986292	1005759	461893.8	506509	123325.556	15838.7739	13514.8
2038	1979487	1805	1981292	1015817	461418.8	521509	123968.889	15680.4038	14014.8
2039	1974487	1805	1976292	1025975	460943.8	536509	124612.222	15523.6173	14514.8
2040	1969487	1805	1971292	1036234	460468.8	551509	120752.222	15368.3988	15014.8
2041	1964487	1805	1966292	1046597	459993.8	566509	121395.556	15214.7324	15514.8
2042	1959487	1805	1961292	1057063	459518.8	581509	122038.889	15062.6027	16014.8
2043	1954487	1805	1956292	1067633	459043.8	596509	124612.222	14911.9942	16514.8
2044	1949487	1805	1951292	1078310	458568.8	611509	125255.556	14762.8919	17014.8
2045	1944487	1805	1946292	1089093	458093.8	626509	125898.889	14615.2806	17514.8
2046	1939487	1805	1941292	1099984	457618.8	641509	126542.222	14469.1454	18014.8
2047	1934487	1805	1936292	1110984	457143.8	656509	127185.556	14324.4715	18514.8

Year	Forest cover	New plantings	Total forest cover including existing and new plantings	Home gardens	Coconut plantations	Tea Plantations	Mixed trees with other perennials	Mangroves	Urban green cover and areas with avenue plants
2048	1929487	1805	1931292	1122093	456668.8	671509	127828.889	14181.2444	19014.8
2049	1924487	1805	1926292	1133314	456193.8	686509	128472.222	14039.4496	19514.8
2050	1919487	1805	1921292	1144648	455718.8	701509	129115.556	13899.0727	20014.8

Table 2: Total Carbon Sequestration in Forests, Trees Outside Forests and Mangroves in the Baseline Scenario (tonnes /yr)

Year	Forests	Trees Outside Forests					Blue Carbon Ecosystems	Total
	In natural forests and plantations	Home gardens	Coconut plantations	Tea lands with shade trees	Mixed trees with other perennials	Urban green cover and areas with avenue plants (ha)	Mangroves	
2025	8661250.2	3345891.493	4047094.2	457112.6	354000	30059.2	415626.713	17311034.4
2026	8638733.2	3379350.408	4042819.2	478112.6	356466.667	32059.2	411470.855	17339012.1
2027	8616216.2	3413143.912	4038544.2	499112.6	356466.667	34059.2	407356.556	17364899.3
2028	8593699.2	3447275.351	4034269.2	520112.6	358396.667	36059.2	403283.4	17393095.6
2029	8571182.2	3481748.105	4029994.2	541112.6	360326.667	38059.2	399250.975	17421673.9
2030	8548665.2	3516565.586	4025719.2	562112.6	361506.333	40059.2	395258.875	17449887
2031	8525665.2	3551731.242	4021444.2	583112.6	362964.667	42059.2	391306.695	17478283.8
2032	8502665.2	3587248.554	4017169.2	604112.6	364423	44059.2	387394.038	17507071.8

Year	Forests	Trees Outside Forests					Blue Carbon Ecosystems	Total
	In natural forests and plantations	Home gardens	Coconut plantations	Tea lands with shade trees	Mixed trees with other perennials	Urban green cover and areas with avenue plants (ha)	Mangroves	
2033	8479665.2	3623121.04	4012894.2	625112.6	365881.333	46059.2	383520.507	17536254.1
2034	8456665.2	3659352.25	4008619.2	646112.6	367339.667	48059.2	379685.711	17565833.8
2035	8433665.2	3695945.773	4004344.2	667112.6	368798	50059.2	375889.263	17595814.2
2036	8410665.2	3732905.23	4000069.2	688112.6	370256.333	52059.2	372130.78	17626198.5
2037	8387665.2	3770234.283	3995794.2	709112.6	371714.667	54059.2	368409.882	17656990
2038	8364665.2	3807936.625	3991519.2	730112.6	373173	56059.2	364726.192	17688192
2039	8341665.2	3846015.992	3987244.2	751112.6	374631.333	58059.2	361079.34	17719807.9
2040	8318665.2	3884476.152	3982969.2	772112.6	376089.667	60059.2	357468.956	17751841
2041	8295665.2	3923320.913	3978694.2	793112.6	377548	62059.2	353894.675	17784294.8
2042	8272665.2	3962554.122	3974419.2	814112.6	379006.333	64059.2	350356.138	17817172.8
2043	8249665.2	4002179.663	3970144.2	835112.6	380464.667	66059.2	346852.986	17850478.5

Year	Forests	Trees Outside Forests					Blue Carbon Ecosystems	Total
	In natural forests and plantations	Home gardens	Coconut plantations	Tea lands with shade trees	Mixed trees with other perennials	Urban green cover and areas with avenue plants (ha)	Mangroves	
2044	8226665.2	4042201.46	3965869.2	856112.6	381923	68059.2	343384.865	17884215.5
2045	8203665.2	4082623.475	3961594.2	877112.6	383381.333	70059.2	339951.426	17918387.4
2046	8180665.2	4123449.709	3957319.2	898112.6	384839.667	72059.2	336552.321	17952997.9
2047	8157665.2	4164684.207	3953044.2	919112.6	386298	74059.2	333187.207	17988050.6
2048	8134665.2	4206331.049	3948769.2	940112.6	387756.333	76059.2	329855.745	18023549.3
2049	8111665.2	4248394.359	3944494.2	961112.6	389214.667	78059.2	326557.597	18059497.8
2050	8088665.2	4290878.303	3940219.2	982112.6	390673	80059.2	323292.43	18095899.9

Table 3: The total GHG emissions from the forestry sector including forests and trees outside forests (tonnes /yr) in the Baseline Scenario from 2025-2050.

Year	From Deforestation	From the fragmentation of coconut lands	From the removal of home gardens	From the removal of mangroves	Total emissions
2025	750000	161250	402860.591	26803.1	1340913.69
2026	750000	161250	406889.197	26535.09	1344674.29
2027	750000	161250	410958.089	26269.77	1348477.86
2028	750000	161250	415067.67	26007.1	1352324.77
2029	750000	161250	419218.346	25747.05	1356215.4
2030	750000	161250	423410.53	25489.61	1360150.14
2031	750000	161250	427644.635	25234.74	1364129.37
2032	750000	161250	431921.081	24982.42	1368153.5
2033	750000	161250	436240.292	24732.62	1372222.91
2034	750000	161250	440602.695	24485.32	1376338.02
2035	750000	161250	445008.722	24240.49	1380499.22
2036	750000	161250	449458.809	23998.12	1384706.92

Year	From Deforestation	From the fragmentation of coconut lands	From the removal of home gardens	From the removal of mangroves	Total emissions
2037	750000	161250	453953.397	23758.16	1388961.56
2038	750000	161250	458492.931	23520.61	1393263.54
2039	750000	161250	463077.861	23285.43	1397613.29
2040	750000	161250	467708.639	23052.6	1402011.24
2041	750000	161250	472385.726	22822.1	1406457.82
2042	750000	161250	477109.583	22593.9	1410953.49
2043	750000	161250	481880.679	22367.99	1415498.67
2044	750000	161250	486699.485	22144.34	1420093.82
2045	750000	161250	491566.48	21922.92	1424739.4
2046	750000	161250	496482.145	21703.72	1429435.86
2047	750000	161250	501446.967	21486.71	1434183.67
2048	750000	161250	506461.436	21271.87	1438983.3
2049	750000	161250	511526.051	21059.17	1443835.22
2050	750000	161250	516641.311	20848.61	1448739.92

Table 4: The projected extents of forests, trees outside forests and mangroves (ha) from 2025-2050 in the Net Zero Scenario

Year	Forest cover	New plantings	Total forest cover including existing and new plantings	Home gardens	Coconut plantations	Tea Plantations	Mixed trees with other perennials	Mangroves	Urban green cover and areas with avenue plants
2025	2043962	9212	2053174	895245.8	547960.8	326509	118000	17966.9723	9514.8
2026	2039067	9212	2048279	904198.2	547485.8	341509	118822.222	18066.9723	12014.8
2027	2034172	9212	2043384	913240.2	547010.8	356509	118822.222	18166.9723	14514.8
2028	2029277	9212	2038489	922372.6	546535.8	371509	119465.556	18266.9723	17014.8
2029	2024382	9212	2033594	931596.3	546060.8	386509	120108.889	18366.9723	19514.8
2030	2019487	9212	2028699	940912.3	545585.8	401509	118822.222	18466.9723	22014.8
2031	2015487	9212	2024699	950321.4	545110.8	416509	119465.556	18566.9723	24514.8
2032	2011487	9212	2020699	959824.6	544635.8	431509	120108.889	18666.9723	27014.8
2033	2008487	9212	2017699	969422.9	544160.8	446509	120752.222	18766.9723	29514.8
2034	2005487	9212	2014699	979117.1	543685.8	461509	121395.556	18866.9723	32014.8
2035	2003487	9212	2012699	988908.3	543210.8	476509	122038.889	18966.9723	34514.8

Year	Forest cover	New plantings	Total forest cover including existing and new plantings	Home gardens	Coconut plantations	Tea Plantations	Mixed trees with other perennials	Mangroves	Urban green cover and areas with avenue plants
2036	2001487	9212	2010699	998797.4	542735.8	491509	122682.222	19066.9723	37014.8
2037	2000487	9212	2009699	1008785	542260.8	506509	123325.556	19166.9723	39514.8
2038	1999487	9212	2008699	1018873	541785.8	521509	123968.889	19266.9723	42014.8
2039	1998987	9212	2008199	1029062	541310.8	536509	124612.222	19366.9723	44514.8
2040	1998487	9212	2007699	1039353	540835.8	551509	120752.222	19466.9723	47014.8
2041	1998187	9212	2007399	1049746	540360.8	566509	121395.556	19566.9723	49514.8
2042	1997937	9212	2007149	1060244	539885.8	581509	122038.889	19666.9723	52014.8
2043	1997737	9212	2006949	1070846	539410.8	596509	124612.222	19766.9723	54514.8
2044	1997587	9212	2006799	1081554	538935.8	611509	125255.556	19866.9723	57014.8
2045	1997487	9212	2006699	1092370	538460.8	626509	125898.889	19966.9723	59514.8
2046	1997437	9212	2006649	1103294	537985.8	641509	126542.222	20066.9723	62014.8
2047	1997437	9212	2006649	1114327	537510.8	656509	127185.556	20166.9723	64514.8

Year	Forest cover	New plantings	Total forest cover including existing and new plantings	Home gardens	Coconut plantations	Tea Plantations	Mixed trees with other perennials	Mangroves	Urban green cover and areas with avenue plants
2048	1997437	9212	2006649	1125470	537035.8	671509	127828.889	20266.9723	67014.8
2049	1997437	9212	2006649	1136725	536560.8	686509	128472.222	20366.9723	69514.8
2050	1997437	9212	2006649	1148092	536085.8	701509	129115.556	20466.9723	72014.8

Table 5: Net Carbon Sequestration in Forests, Trees Outside Forests and Mangroves in the Net Zero Scenario (tonnes /yr)

	Forests	Trees Outside Forests					Blue Carbon Ecosystems	Total
Year	In natural forests and plantations	Homegardens	Coconut plantations	Tea plantations with shade trees	Mixed trees with other perennials	Urban green cover and areas with avenue plants (ha)	Mangroves	
2025	8698285.2	4297179.635	4770397.2	287327.9	354000	38059.2	444862.234	18890111.4
2026	8675768.2	4340151.431	4766122.2	300527.9	356466.667	48059.2	447338.234	18934433.9
2027	8653251.2	4383552.945	4761847.2	313727.9	356466.667	58059.2	449814.234	18976719.4
2028	8630734.2	4427388.475	4757572.2	326927.9	358396.667	68059.2	452290.234	19021368.9
2029	8608217.2	4471662.36	4753297.2	340127.9	360326.667	78059.2	454766.234	19066456.8
2030	8585700.2	4516378.983	4749022.2	353327.9	361506.333	88059.2	457242.234	19111237.1
2031	8717300.2	4561542.773	4744747.2	366527.9	362964.667	98059.2	459718.234	19310860.2
2032	8698900.2	4607158.201	4740472.2	379727.9	364423	108059.2	462194.234	19360935
2033	8835100.2	4653229.783	4736197.2	392927.9	365881.333	118059.2	464670.234	19566065.9
2034	8821300.2	4699762.081	4731922.2	406127.9	367339.667	128059.2	467146.234	19621657.5

	Forests	Trees Outside Forests					Blue Carbon Ecosystems	
Year	In natural forests and plantations	Homegardens	Coconut plantations	Tea plantations with shade trees	Mixed trees with other perennials	Urban green cover and areas with avenue plants (ha)	Mangroves	Total
2035	8962100.2	4746759.701	4727647.2	419327.9	368798	138059.2	469622.234	19832314.5
2036	8952900.2	4794227.298	4723372.2	432527.9	370256.333	148059.2	472098.234	19893441.4
2037	9098300.2	4842169.571	4719097.2	445727.9	371714.667	158059.2	474574.234	20109643
2038	9093700.2	4890591.267	4714822.2	458927.9	373173	168059.2	477050.234	20176324
2039	9166400.2	4939497.18	4710547.2	472127.9	374631.333	178059.2	479526.234	20320789.3
2040	9164100.2	4988892.152	4706272.2	485327.9	376089.667	188059.2	482002.234	20390743.6
2041	9192720.2	5038781.073	4701997.2	498527.9	377548	198059.2	484478.234	20492111.8
2042	9199070.2	5089168.884	4697722.2	511727.9	379006.333	208059.2	486954.234	20571709
2043	9205650.2	5140060.573	4693447.2	524927.9	380464.667	218059.2	489430.234	20652040
2044	9212460.2	5191461.178	4689172.2	538127.9	381923	228059.2	491906.234	20733109.9
2045	9219500.2	5243375.79	4684897.2	551327.9	383381.333	238059.2	494382.234	20814923.9

	Forests	Trees Outside Forests					Blue Carbon Ecosystems	
Year	In natural forests and plantations	Homegardens	Coconut plantations	Tea plantations with shade trees	Mixed trees with other perennials	Urban green cover and areas with avenue plants (ha)	Mangroves	Total
2046	9226770.2	5295809.548	4680622.2	564527.9	384839.667	248059.2	496858.234	20897487
2047	9234270.2	5348767.644	4676347.2	577727.9	386298	258059.2	499334.234	20980804.4
2048	9234270.2	5348767.644	4672072.2	590927.9	387756.333	268059.2	501810.234	21003663.7
2049	9234270.2	5348767.644	4667797.2	604127.9	389214.667	278059.2	504286.234	21026523.1
2050	9234270.2	5348767.644	4663522.2	617327.9	390673	288059.2	506762.234	21049382.4

Table 6: The total GHG emissions from the forestry sector including forests and trees outside forests in the Net Zero Scenario from 2025-2050.(Tonnes/yr)

Year	From Deforestation	From the fragmentation of coconut lands	Total Emissions
2025	750000	161250	911250
2026	750000	161250	911250
2027	750000	161250	911250
2028	750000	161250	911250
2029	750000	161250	911250
2030	750000	161250	911250
2031	600000	161250	761250
2032	600000	161250	761250
2033	450000	161250	611250
2034	450000	161250	611250
2035	300000	161250	461250
2036	300000	161250	461250
2037	150000	161250	311250
2038	150000	161250	311250
2039	75000	161250	236250
2040	75000	161250	236250
2041	45000	161250	206250
2042	37500	161250	198750
2043	30000	161250	191250
2044	22500	161250	183750
2045	15000	161250	176250
2046	7500	161250	168750

2047	0	161250	161250
2048	0	161250	161250
2049	0	161250	161250
2050	0	161250	161250

ANNEXURE 7: GENDER AND SOCIAL ASPECTS OF CARBON NET ZERO GOAL

Social Aspects of Net Carbon Zero Goal

It has been established that energy efficient and lower – carbon living conditions and work settings have far reached impacts. Health benefits and corresponding increased work hours, higher levels of productivity, subtle benefits such as social inclusion and improved accessibility due to energy efficient building and transport, and increased employment due to the demand for skilled labor in building construction and maintenance are among the key advantages identified as resulting from low-carbon settings (Gouldson, A, et. al.2018). The same study also emphasizes on the substantial role of sustainable cities in lowering the level of carbon emission and its positive consequences on the social and economic lives of the people (Gouldson, A, et.al. 2018). The report stresses the implications of energy-efficient buildings, low-carbon transport and effective solid waste management as having a crucial impact on the well-being of people and sustainable development.

Research has highlighted the co-benefits of low-carbon futures including its health benefits and resulting quality of life and its contribution to increased productivity, employment generation and reducing socio-economic vulnerabilities. However, the report also deliberates on the unequal consequences such efforts could produce due to demographic factors, geographical location, economy, employment situation etc. (EEA 2021).

Literature also demonstrates that social harmony (ethnicity, religion based), social class, gender, political stability and good governance, social policy and institutional well-being and also domestic life styles have direct and indirect relationships with the carbon emission in a society. Wang et al. (2020), studied "how environmental performance is affected by economic, political and social indicators by using the annual data of 163 developed and developing countries covering the time period of 1996-2016. According to Wang et. al. (2020), ethnic diversity; institutional quality and political freedom play a significant role in decreasing CO2 emissions while energy consumption, GDP growth and financial development are seen as factors contributing to increased environmental degradation".

In a study conducted in Nigeria on the impact of population growth on carbon dioxide emission, Lawal (2019) examines time series data from 1975 to 2016 demonstrating a positive correlation between carbon emission, population and technology while establishing a negative association between affluence and carbon dioxide emissions. The study sees population growth as having only a marginal impact on the level of carbon emission. This finding goes against some other research where population growth, economic development and wealth are seen as factors contributing to higher carbon emissions.

Studies have demonstrated that higher military expenditures cater to increased environmental impacts including greater levels of carbon dioxide emissions (Jorgenson and Clark, 2009; York, 2008, as cited in Ergas and York, 2012). However, Ergas and York in their 2012 study states the nations with higher military expenditure do not necessarily cater to higher carbon emissions but also could be equal with other nations (Ergas and York, 2012).

Using time series data for 37 years from 1974 to 2010 to analyze the causal relationship between environmental pollution, education and economic growth in Bangladesh, Uddin (2014) has shown the presence of statistically significant correlation between carbon dioxide emission and education expenditure. He posits that higher share in GDP for education, via increased literacy and awareness among population, contribute to reduced emissions and resulting sustainable development.

Recent developments in worldwide online education due to Covid pandemic has directed the attention of researchers towards the environmental impact of social changes accompanying this process. Conducting a case study in Chinese universities taking two main elements related to online education, transportation and electricity consumption into consideration, Yin *et al.* (2022) say that online education can significantly reduce lower carbon emission. The study reveals that in the field of higher education alone, if the first calculation result of this study (i.e.,1,459,596.596 tons) is used "the total carbon emissions reduction of college students caused by online education during the half-year is equivalent to the total carbon emissions in 1.296 h in China, 2.688 h in the United States, 5.544 h in India, 12 h in Japan and 3.864 h in European countries of OECD" (Yin et.al., 2022:11).

A study conducted by Benlemlih, Assaf, and El Ouadghiri (2022) provides strong evidence on the positive relationship of low carbon emission and political stability and lesser corruptive practices. Examining data sets from 145 countries worldwide, the researchers have pointed out that in the short run, carbon dioxide emissions become substantially reduced with high political stability.

Drawing information from over 700 research papers, Gouldson et al. (2018), explains that low-carbon measures would cater to a range of achievements including job creation, improved public health, social inclusion, and improved accessibility. The author further claims that green building structure would contribute to as much as a 16 percent increase in worker productivity while playing an important role in the reduction of poverty and inequality, providing job opportunities in the fields of recycling programmes, low carbon waste management projects etc.

Carbon Emission and Gender

Many studies have demonstrated the gendered differences in the contribution to carbon emission and the gendered impact of carbon levels (Lee et.al. 2017; Li et. al. 2019; Castañeda et.al. 2020, Nuber, 2021; WOW, 2021). Researchers also have explicated that women's higher representation in politics as a significant factor in reducing carbon emission (Benlemlih, Assaf, and El Ouadghiri 2022).

Utilizing a large-scale survey of 100,956 respondents across 37 countries Imbulana Arachchi and Managi (2021) shows the existence of a significant contrast between males and females with regard to the knowledge concerning sustainability and energy saving practices. According to this study, in most countries males seem to be more knowledgeable about energy sustainability than females. However, females were found to be more concerned about the importance of energy sustainability than males.

The authors say that male tendency in looking for cause-effect logic and the female tendency in holistic association could be integrated in the decision-making process concerning energy sustainability and energy conservation practices producing better energy conservation models.

A strong connection has been made between women's participation in the decision-making processes and Lower carbon emission. A survey conducted in Canada has shown that firms comprising a higher female working population demonstrated a higher concern on green gas effects than in firms with a higher male presence (Ghaeli, 2019).

According to IUCN data, women have held 15% top level jobs as ministers of environmental sectors in 2020 compared to 12 percent in 2015 revealing an incremental change over time regarding women's involvement in decision making related to the environment (IUCN, 2022). IUCN reports also reveal that countries with more women in their parliaments are more likely to ratify environmental treaties and invest in and conserve land for renewable power generation.

According to a fairly large study that took a sample of the 329 largest companies in the United Kingdom into consideration, Liao, Luo and Tang (2015) demonstrated a significant positive association between gender diversity when measured as the percentage of female directors on the board. The study also reveals that the propensity to disclose GHG information and the extensiveness of that disclosure is higher when the female percentage is higher among the Board of directors.

A study conducted by Haque (2017) covering a period of 13 years between 2002 – 2014 examining the effects of board characteristics and sustainable compensation policy on carbon reduction initiatives and greenhouse gas (GHG) emissions of a firm suggested that board independence and board gender diversity have positive associations with carbon reduction initiatives.

IUCN based on studies carried out in West Africa have shown that women have shown a tendency to use agricultural techniques that would better adapt to climate change IUCN (2022), The studies also explicate that women are more likely than men to engage in group decisions catering to better conservation practices and land management extending such contributions to the fields of scientific, business and political decision making.

The Paris agreement takes a holistic view on climate change recognizing climate change as a common concern of humankind. It expects the parties to the agreement to respect, promote and consider their respective obligations on human rights (UNFCCC, 2016) in acting towards addressing climate change.

Article 7 of the Paris agreement requires the parties to follow a country-driven, gender-responsive, participatory and fully transparent approach, taking into consideration vulnerable groups, communities and ecosystems in taking climate action. It also encourages taking into consideration traditional knowledge, knowledge of indigenous peoples and local knowledge systems where appropriate (UNFCCC, 2016). Article 7 also has paid attention to the importance of building resilience of socioeconomic and ecological systems when reaching its goal of sustainable management of natural resources. The success in achieving the carbon net zero goal therefore, would significantly depend on the planning and implementation process at the country level. However, this target would be effective only if and when the country is committed to take a country driven, gender responsive path based on scientific as well as indigenous knowledge that incorporates the total scenario surrounding carbon emission concerning all people of the country including vulnerable communities.

In July 2021, as a signatory to the Paris Agreement, The Ministry of Environment in Sri Lanka published an updated version of the Nationally Determined Contributions (NDCs) to the United Nations Framework Convention on Climate Change (UNFCCC). Being placed at a high rank in the Global Climate Risk Index due to its tropical weather conditions and facing ensuing vulnerabilities despite its low – carbon emission records, Sri Lanka's contribution to environmental conservation becomes a high priority in order to maintain economic and social well-being of its population. The risks become augmented with the increasing urbanization and resulting demand for resources further endangering its already frail ecosystems.

While considering the sectors such as industry, energy, waste, forestry and agriculture as major priorities in the project for lowering carbon emission, the NDC document also has duly paid attention to socio-economic and gender factors. It says that "Investments in mitigation will be prioritized based on emission intensities and the economic, social or environmental co-benefits derived from these actions" (Ministry of Environment, 2021:1) catering to the target of keeping "the country on a low carbon trajectory as it strives for greater economic and social well-being of its people" (Ministry of Environment, 2021: 1).

NDC have considered the significance of considering the gender impacts of any measures taken to lower Net Zero Carbon Emission. In the Chapter 4 of NDCs on Implementing and Monitoring Mitigation, it is recommended that in targeting sustainable development measures it is necessary to conduct "detailed gender and social analyses of the actions and propose any mitigatory steps to overcome risks" and emphasizes that "Gender and sustainable development co-benefit analysis is mandatorily required in Sri Lanka's national planning project format" (Ministry of Environment, 2021:7).

Chapter 5 of NDCs document which discusses the adaptation process" (Ministry of Environment, 2021:25), it considers the mainstreaming of gender and social safeguards into adaptation priorities as an important strategy. While it is recommended that "down-scaled risk assessments and sectoral plans integrate specific needs, vulnerabilities and capacities of women, young children, disabled and elderly populations", it highlights the need for developing gender-responsive strategies "taking into account differentiated needs of men and women within the sector and recommend ways to improve access to knowledge, technology, financing etc. in a way that creates enabling conditions for adaptation". It further cites the importance of "Increased capacities among both men and women, improved technical and Science, Technology, Engineering and Mathematics (STEM) education, more funding for vulnerability analysis at the local level etc., to enable greater engagement and contribution of women, allowing the application of skills and capacities that are gender-specific (Ministry of Environment, 2021: 25).

NDCs also stresses the need to invest in gender-responsive training promoting equal contribution by women and ensuring equal access to benefits. It says that "Gender-responsive NDCs will enable men and women to equally benefit from new technologies, climate-smart production and water management practices that would include better agriculture productivity, food security and incomes, greater resource management efficiency (water, land, food processing and preservation) etc." (Ministry of Environment, 2021: 25) and recommends that the sectors undertake detailed gender analysis in developing ten-year NDC implementation plans. While chapter 7 has substantially been dedicated to the aspect of integrating gender and sustainable development to NDCs, it pays attention to the gender concerns in the entire process in decision making, implementation and monitoring. It has contemplated on the necessity of prioritizing gender and being gender responsive in the efforts to lower GHG emissions while maintaining gender balance at all bodies catering to this cause (Ministry of Environment, 2021: 50).

One of the main concerns of the Paris Agreement is to promote gender equality and women's empowerment and adopt gender-responsive approaches in adaptations of policies and planning and implementation of climate related actions. The UNFCCC Gender Action Plan also recommends gender mainstreaming in all climate change processes. Being on par with these international treaties on climate change, NDCs of Sri Lanka stresses the need to analyze gender disparities from a national development context, "to narrow down existing disparities and identify ways to realize the optimum potential of men and women through climate action" and benefit from the knowledge and capabilities of both men and women in implementing mitigation and adaptation measures (Ministry of Environment, 2021: 50). Placing this process alongside with the national gender equality and women empowerment agenda, National Steering Committee (NSC) has been established to ensure synergies between climate action and other sustainable development goals – including gender equality and women's empowerment" which "are identified as preconditions for the successful implementation of the N and the achievement of the SDGs" (Ministry of Environment, 2021:55). Therefore, the NSCs are expected to ensure that the SDG achievements are not hampered by any mitigation measures taken in climate action in the implementation of NDCs.

NDCs in chapter 5, gender-based actions have been mentioned as a priority only in relation to the livestock sector. NDC recommends the promotion of gender sensitivity in the livestock sector as a major target for the year 2022. No other mentioning of gender-based activity could be identified in the sectoral adaptation of NDCs.

Apparent exclusion of gender and other social sector priorities in natural disasters in the calculations made by different organizations including the World Bank in the predictions made on the potential impacts due to climate change by 2050 has been identified as a gap by the NDC Sri Lanka (Ministry of Environment, 2021: 47). Therefore, it could be estimated that the losses incurred due to climate change by 2050 could be much higher than the currently available estimates. This calls for adequate attention to social and gender issues prevailing in the spheres of climate and environment. In addressing this serious gap in identifying the damages, NDC recommends aligning climate actions with sustainable development goals.

According to the NDC document, effective NDC implementation and investments in mitigation are supposed to be prioritized based on emission intensities and the economic, social or environmental co-benefits derived from these actions. NDCs in Sri Lanka have identified a number of key sectors; viz. agriculture, livestock, fisheries, water, health, biodiversity, coastal and marine, urban planning and human settlements, and tourism for which priority should be given in designing adaptation needs and resilience-building activities with the goal of keeping " the country on a low carbon track as it strives for the greater economic and social well-being of its people (Ministry of Environment, 2021: 1).

When implementing and Monitoring Mitigation NDCs it is mandatory to carry out a gender and sustainable development co-benefit analysis for national planning projects and to conduct environmental and social impact assessments for all projects that involve larger scale land conversion or infrastructures. (Ministry of Environment, 2021:7)

Agreed upon at the United Nations Conference on Sustainable Development in 2012, the Sustainable Development Goals (SDGs) were adopted by the United Nations in 2015 in order to create a global agenda addressing the environmental, political and economic challenges the world has faced hindering the goals of development. The seventeen objectives chosen to be the goals of sustainable development which are to be achieved during the period between 2015 – 2030 consider that for the development to be sustainable, all these aspects including positively responding to the negative impacts of climate change, sustainable management of fragile natural resources, reducing inequalities and promoting peace as priorities that are interrelated and need urgent action.

UN Environment Program has highlighted the importance of addressing environmental issues through each of the SDGs. According to UNEP (2020), SDG 5 which is "Achieve Gender Equality and Empower All Women and Girls" has identified its Target 5.a: as to "Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws." This target treats the relationship between women and their natural environment in reaching sustainable development and the importance of addressing these issues as a priority concern. Since the rural labour force comprises mainly of women, and their livelihoods are mostly based on natural resources, considering women's relationship to environment as a priority in targeting SDGs become a prime concern in the environmental conservation including climate action. SDG indicators that address the issue of empowerment of women under this scenario would become a clear measurement of the relationship between women's social position and its contribution to environment conservation.

SDGs also attempt to address the prevailing inequalities in countries that would become a significant measure in addressing the environmental and climatic issues related to such inequalities. SDG 10 is particularly designed with the goal of reducing inequality within and among countries. Its target 10.3 claims to "ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard". This can be considered a central theme in making any development sustainable as the most vulnerable could be reaping the worst impact of environmental degradation and climate change exacerbating the existing vulnerabilities.

Sri Lanka is one of the countries which has shown a clear commitment towards reaching SDGs by 2030. Out of the 17 SDGs, SDG 5: Gender Equality, SDG 8: Decent Work and Economic Growth, SDG10: Reduced Inequalities, SDG 11: Sustainable Cities and Communities and SDG 13: Climate Action are of prime importance in reaching carbon net zero through gender equality and social inclusion. Nevertheless, all SDGs seem to contribute to carbon net zero target directly or indirectly by increasing affordability of the population resulting in increased use of renewable energy sources, reduced dependence on natural resources and active decision making, planning and implementation of ecofriendly development goals.

Even though the above is the positive picture the country is anticipated to accomplish, UN Women (2021) claims,

> "As of December 2020, only 40.9% of indicators needed to monitor the SDGs from a gender perspective were available, with gaps in key areas, in particular: unpaid care and domestic work and information and communications technology skills. In addition, many areas – such as gender and poverty, physical and sexual harassment, women's access to assets (including land), and gender and the environment – lack comparable methodologies for regular monitoring. Closing these gender data gaps is essential for achieving gender-related SDG commitments in Sri Lanka".

According to UN Women (2021), Sri Lanka so far has not been able to achieve the goals of gender equality as envisaged. Women do not seem to have adequately entered into decision making bodies. Women only held 10.89 percent of elected seats in bodies of local government while the representation of women in national parliaments was 5.38 percent of total number of seats as of 2021. Only 25.97 percent of the managerial positions were held by women showing an overall low performance of women's entry into decision making bodies. Moreover, UN Women (2021) reveals that even though a slight increase in number of parliamentary membership of women could be seen, a declining trend is visible in the percentage of women employed in managerial positions. Despite the high performance level shown by Sri Lanka with regard to the presence of "laws and regulations that guarantee full and equal access to women and men aged 15 years and older to sexual and reproductive health care, information and education" which is 89 percent, and equal access to contraceptive and family planning which is 100 percent, low performance of 63 percent has been identified in maternity care which would affect women's health and wellbeing and their upward carrier mobility. Such circumstances which add to women's impaired health and hindered access to opportunities would not produce the anticipated positive input of women in politics (Benlemlih, Assaf, and El Ouadghiri, 2022) and decision-making levels (Ghaeli, 2019; IUCN, 2022) in reducing carbon emissions.

Further to the situation, under SDG 8: Decent Work to Economic Growth, UN Women (2021) reports that the unemployment rate of the country for the people over the age of 15 is increasing for both men and women (4.3%), however, women's unemployment rate (6.9%) is comparatively higher than that of men (3%).

It has been further revealed that the country has experienced an age-standardized mortality rate of 63 deaths per 100,000 population which is attributed to household air pollution (UN Women, 2021) is a consequence of low health and wellbeing due to many factors including overcrowding, lack of enough space, use of fossil fuel and energy sources, use of excessive amounts of firewood in smaller and closed environments etc. The report also says that the proportion of population with primary reliance on clean fuels and technology is only 31 percent. Lower use of renewable energy sources could be attributed to poverty and the high cost of installing solar power systems and other renewable energy sources, low awareness and lack of formal initiatives in popularizing sustainable household energy sources.

Gender and social scenario under these circumstances does not seem to reap the probable contribution that a larger and empowered female population or an educated population could have to the lowering of carbon emission unless specific attempts are made to uplift the socio-economic status of the underprivileged and vulnerable groups and attain gender equality with a focus on the reduction of carbon emission practices during the everyday lives of the country's population.

One of the major issues that have been highlighted with regard to gender and environmental concerns in SDGs is that although SDGs have paid substantial attention to the significance of the gender as well as the environment in achieving sustainability in development, they have not considered the inseparable link between these two factors. UN Policy brief 002 of UNEP (2018) referring to the absence of gender disaggregated data says that "The SDG Global Indicator Framework is gender blind in SDGs 6, 7, 9, 12, 14 and 15". All these indicators are concerned with environmental factors or possible pollutants of the environment, thus revealing the failure of the policy making level to capture the need to see the synergies between gender and environment. Such an approach at the level of policy could lead the countries to ignore this vital relationship and the capacity to utilize it for the protection of environment.

Summary of the views provided by the respondents

- Speaking of their experience with climate change, all the respondents shared that they encountered some consequences of carbon emission, including irregular temperature and rain patterns. In addition to this, rural people often experience the scarcity of water due to the drying of lakes, droughts, loss of vegetation etc. However, except for a few educated respondents, others did not understand the relationship between climate change and carbon emission.
- However, they could see the connection between human activities that can increase climate change, such as deforestation, vehicle emission, improper disposal of garbage, and industrialization and improper disposal of factory waste into the natural ecosystems.
- Three rural respondents including two males and a female with middle income highlighted the fact that there is a dire need for an effective waste collecting system in rural areas. They were of the view that lethargic attitude of the concerned authorities in collecting waste from rural areas lead people to adopt environmentally harmful activities such as burning of non-biodegradable waste.
- Respondents from the rural sector largely pointed out the problems concerning the disposal of chemical waste into the waterways and its impact on the increase of kidney disease in rural settings.
- Other than a few respondents from a rural low-income background who possessed less knowledge on solar energy, both urban and rest of the rural respondents prefer shifting to solar energy if it can be affordable. Dry zone respondents claimed that their climate with high temperatures would provide a perfect ground for generating solar energy. They suggested the introduction of loan scheme for this purpose enabling them to use this freely available source of renewable energy.
- It is important to mention here, even though the suggestion came from one respondent, who is a middle-income male in urban settings, that in order to make solar energy a popular source of renewable energy, it is highly important to focus on people's infrastructure, including proper roofing, to plant solar panels. According to him, if the government does not prioritize this issue, the urban low-income population living in substandard housing will be unable to reap the benefits of renewable energy, despite receiving government assistance to use solar energy. Another urban middle-income male pointed out that even though he prefers using solar energy, the average lifetime of a solar panel would be 10–12 years. He stated that the approximate cost needed to plant a small solar panel would be nearly 1,500,000–2,000,000 LKR which is not affordable by many middle-class people including himself.
- Rural middle-class respondents in agriculture claimed that they do not have a clear idea on the ability to use solar energy in agricultural activities are less knowledgeable about introducing this initiative to agricultural activities. They are eager to reap the benefits of the newly introduced green agricultural techniques if the government can properly implement this initiative with correct guidelines for using solar-energy driven agricultural appliances.

- However, they stressed the negative repercussions they reaped due to the ineffective decisions taken by the government in completely banning chemical fertilizers and introducing organic fertilizer as an alternative in 2021. According to one rural middle-income farmer and one rural middle-income female engaged in agriculture, this sudden decision caused them to face a slew of problems, including receiving low-quality organic fertilizer, losing more than half of their harvest, losing income, going into debt, etc. According to their experience-based knowledge, organic fertilizer could be more effective for home-based plantations but when it comes to large scale, it is not quite practical. However, they were aware of the environmental destruction that could cause by chemical fertilizers.
- Their suggestion was that if the government could provide high-quality organic fertilizer, they could use it for approximately 70% of the crop, along with 30% for chemical fertilizer according to their experience. They did not see the possibility to totally convert to organic fertilizers at the moment, as it is impossible to kill weeds and pests in a paddy field just with organic agricultural products. They suggested that a gradual shift to decrease the use of chemical fertilizers would be far more effective.
- Both rural and urban people talked about their practices that might contribute to climate change. The main activities mentioned by the urban population was the burning of plastics and the heavy use of polythene. Furthermore, a small number of rural respondents blame the urban middle-income population for their unhealthy practices, such as dumping waste in rural forestry areas and engaging in construction and industrial activities that may worsen environmental degradation.
- People in general have less knowledge about the 3R concept, but some of their practices indicate that they follow some environmentally friendly actions although they were unaware of the related technicalities. Using reusable bags, categorizing waste before disposing of it, reducing food waste by buying what we need, composting food waste, donating unused food to the needy or shelters, and reusing or recycling items such as old clothes, cloth grocery bags, and containers are some of the practices they mentioned, often practiced as meritorious deeds and cultural practices.
- They also engage in some energy-efficient practices such as working more with electricity during the day, limiting the number of light bulbs, and ironing or washing clothes at once a week. One urban middle-income respondent said that he regularly rides a bicycle for short-distance travel as both an exercise and to reduce vehicle emissions. A rural low-income female claimed that her family members use a bicycle to travel to the city a cost cutting method. Respondents from rural settings often claimed that they use firewood to cook, however, they did not have any understanding of the contribution of the practice to carbon emission. They were of the view that the use of fire wood is an environmentally protective activity.
- However, one rural low-income female had a different conception of canal-based transportation systems. In her view, this could increase water pollution in rural waterways.
- In general, the rural population saw rural living as a healthy measure in conserving nature. Urban population did not see it as an alternative that many urban people would

not be able to revert back to mainly due to their established social networks and career opportunities.

- One rural middle-class female talked about the importance of the concept of "think green before shopping."
- Often, rural respondents were of the view that it is the urban population that pollute the environment resulting in climate change.
- Nevertheless, urban residents claim that they are aware of climate change and its consequences, and thus take more environmentally protective measures.
- In general, every respondent knows the impact of polythene on environmental degradation. Even if so, people, especially women, seem to burn polythene, as measure of destroying waste. They were of the view that it is less environmentally harmful if all polythene bags could be collected and burn once a week or so.
- Speaking of environmental movements, five respondents claimed that they have engaged in environmental activism.
- Respondents from both genders and social classes in both rural and urban areas, were unanimous on the need for an efficient transportation system in the country.
- All the respondents strongly agree on the need for reforestation and increasing forest cover in both rural and urban areas. They blamed the forest-based businesses as the main reason for deforestation. Urban respondents emphasized the responsibility of the government to initiate programs for increasing forest cover in urban areas.
- Working from home to reduce carbon emission was not applicable for the very large rural population due to the nature of their livelihoods. Those who engaged in while collar jobs also were not pleased with the idea mentioning that it is not possible to entirely depend on technology as paper work is still largely practiced. Respondents also stated that it is not easy for them to work from home due to stressful family environment, overworking in relation to gender roles at home, and to the difficulty in detaching entirely from domestic social relations and responsibilities during working hours. One urban middle-income male who is also working in an IT related field said that working from home could be more expensive in terms of high electricity and data expenses, and he prefers to travel to his workplace instead. Only four respondents from the total sample preferred working from home since it could be more cost effective.

Suggestions by the respondents

Urban

- Including practice-based knowledge about environmental conservation and climate change into the school education system
- Government intervention to increase forest cover in urban areas
- The government's proper implementation of the 3Rs.
- Government intervention is needed to promote affordable solar energy.
- A better government action plan to reduce carbon emissions, beginning with households and progressing to large factories

- The government should take the necessary action to promote electric cars.

Rural

- Urban settings should be greener.
- Rural waste management should be effective. Government intervention is crucial.
- Proper garbage collection and dumping plans

ANNEXURE 8: SUPPORTING DATA OF THE ECONOMIC ANALYSIS

1. Energy sector

The proposed actions for energy sector results in carbon emission savings which have been converted into monetary estimates using available social cost of carbon emissions from the World Bank. The following figure shows the net benefits, which are negative.

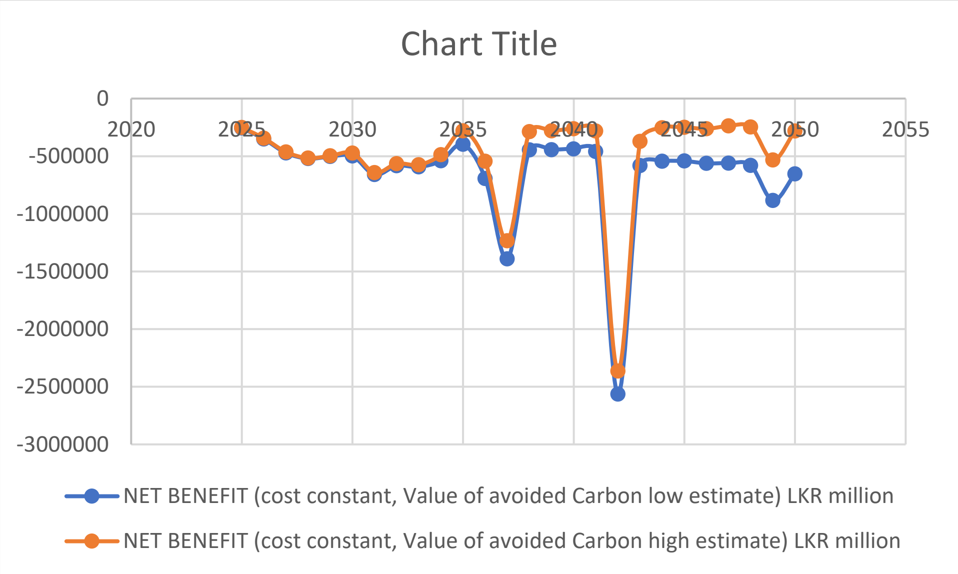


Figure 1. Net benefits from Proposed Mitigation Scenario 02- Energy Sector decarbonization

Above figure indicates that net negative benefits are resulted from the proposed actions for the energy sector due to the high cost of the action. The economic analysis of the action has resulted in net present value as follows for different prices used. The following table provides details.

Table : Net present values of Proposed Mitigation Scenario 02- Energy Sector decarbonization under different prices of avoided carbon and cost escalations

Context	Net present value (LKR) @ 10% discount rate
Net benefit (cost constant, Value of avoided Carbon low estimate)	-5,105,443,005,554.94
Net benefit (cost constant, Value of avoided Carbon high estimate)	-4,412,922,592,073.77

It is necessary therefore to arrange financing mechanisms in order to implement the decarbonisation energy actions for Sri Lanka.

2. Transport Sector

The following emission reduction (ER) actions are proposed under the net zero status in the transport sector.

ER action 1: Railway Electrification

ER action 2: Interprovincial Bus Electrification

ER action 3: Provincial Bus Electrification

ER action 4: Private and Freight Vehicles Electrification

The following section provides details of costs and benefits of each action.

ER action 1: Railway Electrification

Railway electrification results in some emission savings. The following figure illustrates the savings for the period from 2030 to 2050.

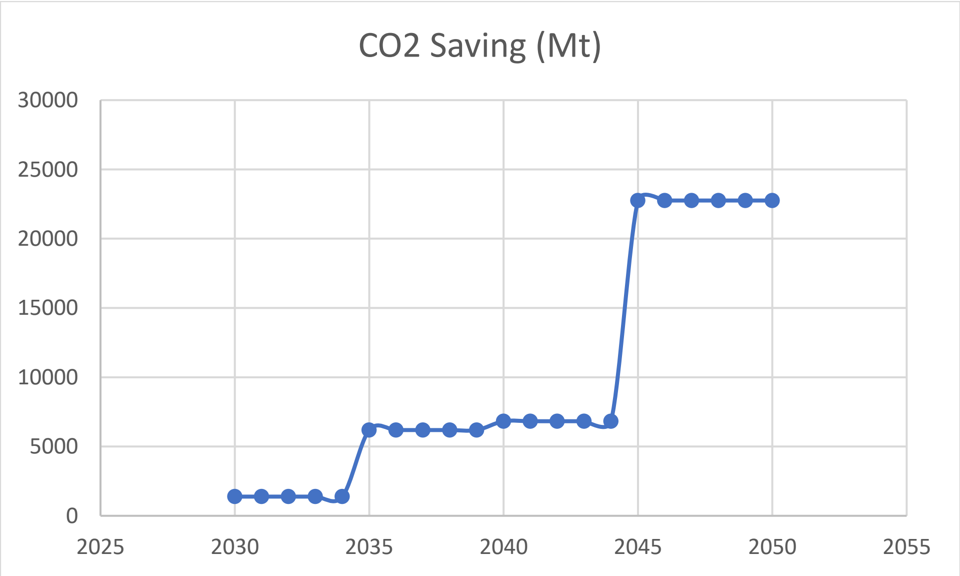


Figure 2: CO2 savings from Railway electrification for the period 2030 to 2050

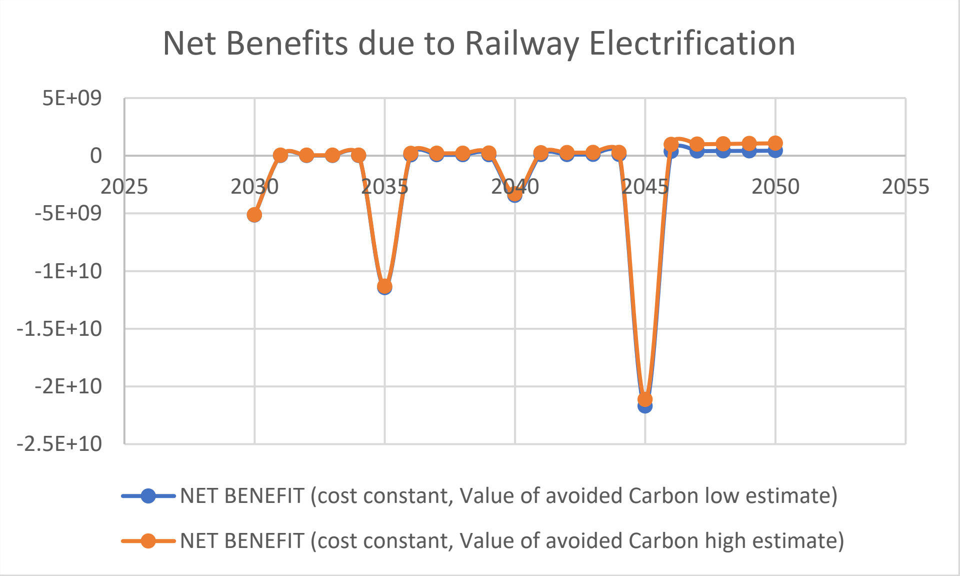


Figure 3: Net Benefits due to Railway Electrification

Above figure indicates that net negative benefits are resulted from the action due to the high cost of the action. The economic analysis of the action has resulted in net present value as follows for different prices used. The following table provides details.

Table : Net present values of using Electric vehicle for Railway Electrification under different prices of avoided carbon

Context	Net present value (LKR) @ 10% discount rate
Net benefit (cost constant, Value of avoided Carbon low estimate)	-16,443,331,238.02
Net benefit (cost constant, Value of avoided Carbon high estimate)	-15,176,037,288.13

The higher operational and capital costs associated with railway electrification makes this action a non beneficial action. The above figure illustrates the higher costs associated with the Railway Electrification. The action results in carbon emission savings which have been converted into monetary estimates using available social cost of carbon emissions from the World Bank.

It is important to estimate a price for the carbon savings to see how this action could be made viable through some type of a resource transferor carbon credits. However, the above calculation has not taken into account the time savings of the commuters, vehicle emission savings etc associated with the improved rail service. In addition there will be health benefits due to the reduced emission of PM 2.5 and other air pollutants.

Similar trends are observed with other actions, which are Interprovincial Bus Electrification, Provincial Bus Electrification and Private and Freight Vehicles Electrification as well.

The following table provides details.

Table: Net present values of proposed Emission reduction **mitigation actions for Transport sectors**

Mitigation actions	**Net Present Value (LKR) @ 10% discount rate**	
	Value of avoided Carbon (lower estimate)	**Value of avoided Carbon (upper estimate**
1. Railway Electrification	-16,443,331,238	-15,176,037,288
2. Interprovincial Bus Electrification	-97,992,697,344	-70,897,175,975
3. Provincial Bus Electrification	-141,288,818,341	-128,430,869,073
4. Private and Freight Vehicles Electrification	-36,292,770,688,495	-35,828,728,616,907
All four actions	-36,548,495,535,418	-36,043,232,699,243

It is therefore essential to find out mechanisms to finance the proposed mitigation measures from international sources.

3. Waste sector

The following emission reduction (ER) actions and sequestration enhancement (SE) actions are proposed under the net zero status in the waste sector.

ER action 1: Syngas recovery from open dump

ER action 2: Electric vehicle for waste collection

ER action 3: Waste to energy plants

ER action 4: Sanitary landfill

SE action 1: Daily Cover for Open dump

SE action 2: Vertical Subsurface flow constructed wetland (VSSFCW)

The following table provides details related to the level of operation and associated unit costs.

Table: Activities/ sub activities, their levels of operation and costs per unit for waste sector

Activity /Sub activity	Level of operation (annual)	Cost per unit
Emission reduction action 1: Syngas recovery from open dump	2031 (10% to 50% by 2050) 71.95 tonnes CO_2eq	0.126 $/Nm^3
	2035 – 628.91 tonnes CO_2eq	
	2040 – 1,464.71 tonnes CO_2eq	
	2045 – 2,598.84 tonnes CO_2eq	
	2050 – 3,463.97 tonnes CO_2eq	
Emission reduction action 2: Electric vehicle for waste collection	2036 – 136.7 tonnes CO_2eq	Electric Compression Garbage Truck US$ 98800-135460
	2040 – 628.83 tonnes CO_2eq	
	2045 – 492.21 tonnes CO_2eq	
	2050 – 355.42 tonnes CO_2eq	
Emission reduction action 3: Waste to energy plants	2036 – 1 No 143,517 tonnes CO_2eq 2041 – 1 No	US$95 million (KCHT Power Station Muthurajawela -2019) 630 tonnes of waste
	2040 – 720,756 tonnes CO_2eq	
	2045 – 1,421,816 tonnes CO_2eq	
	2050 – 1,373,142 tonnes CO_2eq	
Emission reduction action 4: Sanitary landfill	2046 – 118,544 tonnes CO_2eq	The sanitary landfill site at Aruwakkalu is designed to accommodate a capacity of about 5,000,000 tonnes of mixed MSW for 15 years at the cost of around US$ 101 million.
	2050 – 738,404 tonnes CO_2eq	
Sequestration enhancing action 1: Daily Cover for Open dump	2026 – 70,352 tonnes CO_2eq	Rs 2/kg of biochar
	2030 – 366,838 tonnes CO_2eq	
	2035 –437,709 tonnes CO_2eq	
	2040 – 538,461 tonnes CO_2eq	
	2045 – 649,058 tonnes CO_2eq	
	2050 – 769,773 tonnes CO_2eq	
Sequestration enhancing action 2: Vertical Subsurface flow constructed wetland (VSSFCW)	2031 – 4,736 tonnes CO_2eq	Rs. 35 000/Unit Operation Cost
	2036 – 23,463 tonnes CO_2eq	
	2040 – 22,919 tonnes CO_2eq	
	2045 – 22,376 tonnes CO_2eq	
	2050 – 21,832 tonnes CO_2eq	

Emission reduction action 1: Syngas recovery from open dump

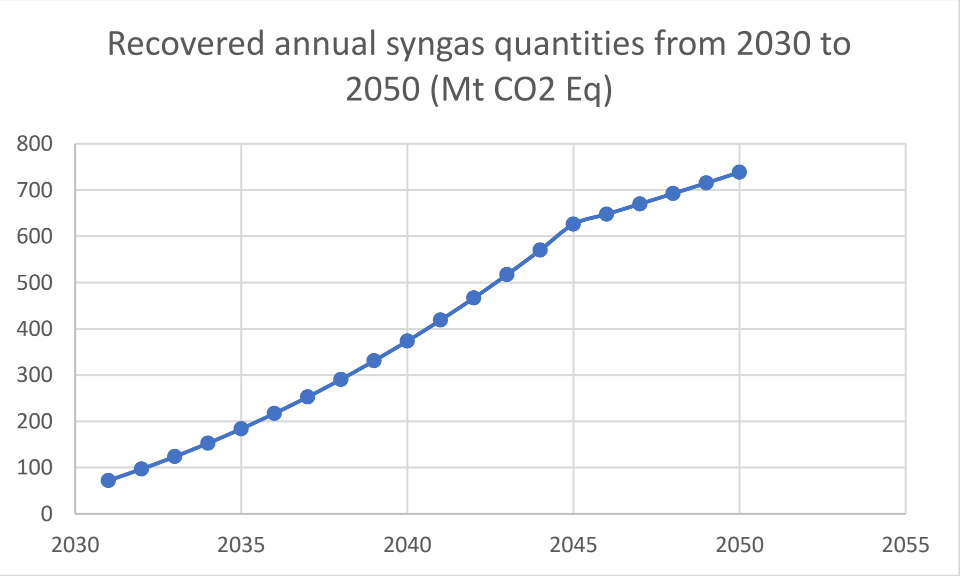


Figure 4 : Recovered annual syngas quantities from 2030 to 2050

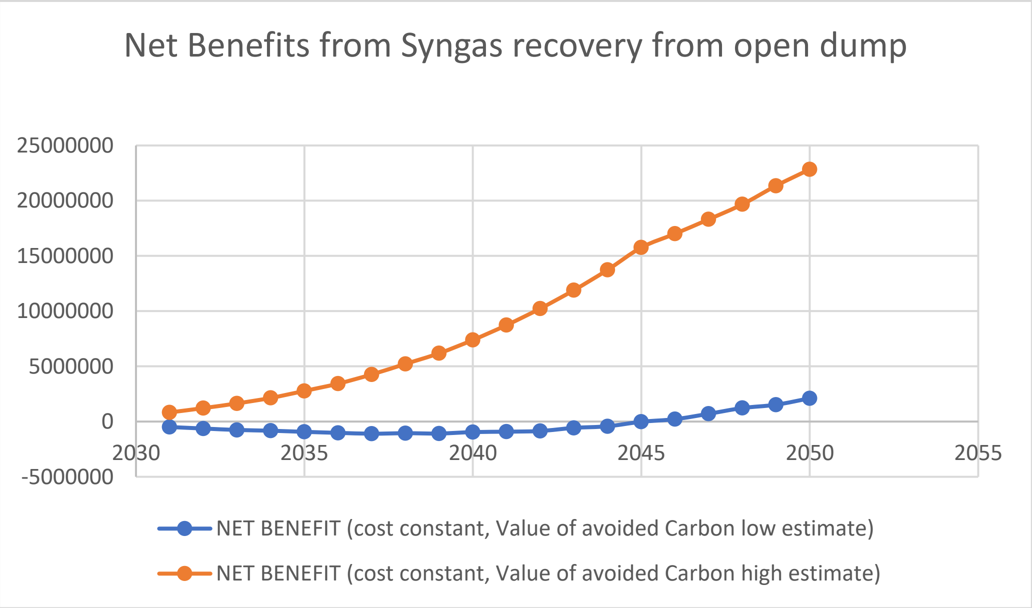


Figure 5 : Net Benefits from Syngas recovery from open dump

Above figure indicates that only the higher estimate of value of avoided carbon shows net positive benefit. The economic analysis of the action has resulted in net present value as follows for different prices used. The following table provides details.

Table : Net present values of syn gas recovery under different prices of avoided carbon and cost escalations

Context	Net present value (LKR) @ 10% discount rate
Net benefit (cost constant, Value of avoided Carbon low estimate)	-5,052,744.20
Net benefit (cost constant, Value of avoided Carbon high estimate)	53,115,328.99
Net benefit (cost 2% increase, Value of avoided Carbon low estimate)	-6,313,657.42
Net benefit (cost 2% increase, Value of avoided Carbon high estimate)	51,854,415.77

Emission reduction action 2: Electric vehicle for waste collection

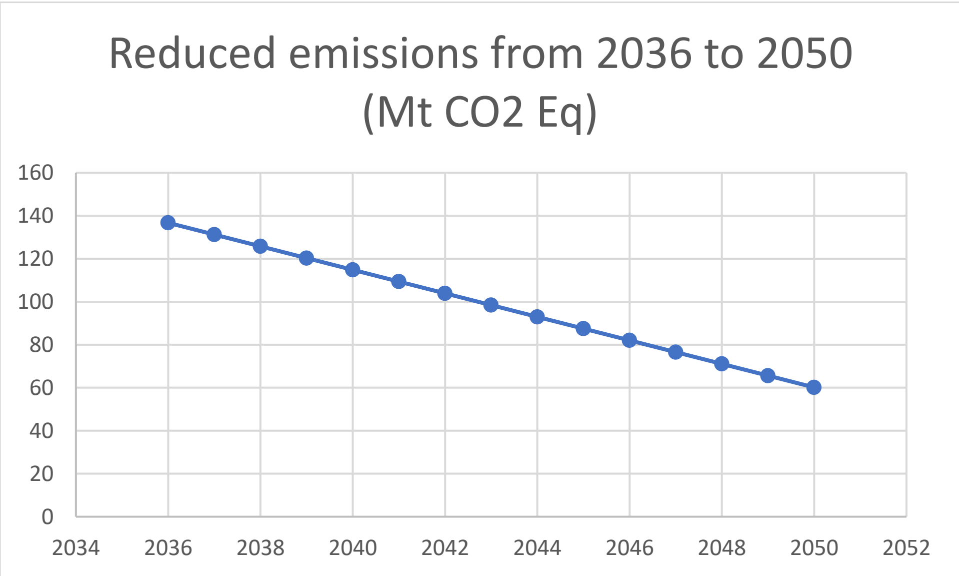


Figure 6 : Reduced emissions due to electric vehicle for waste collection

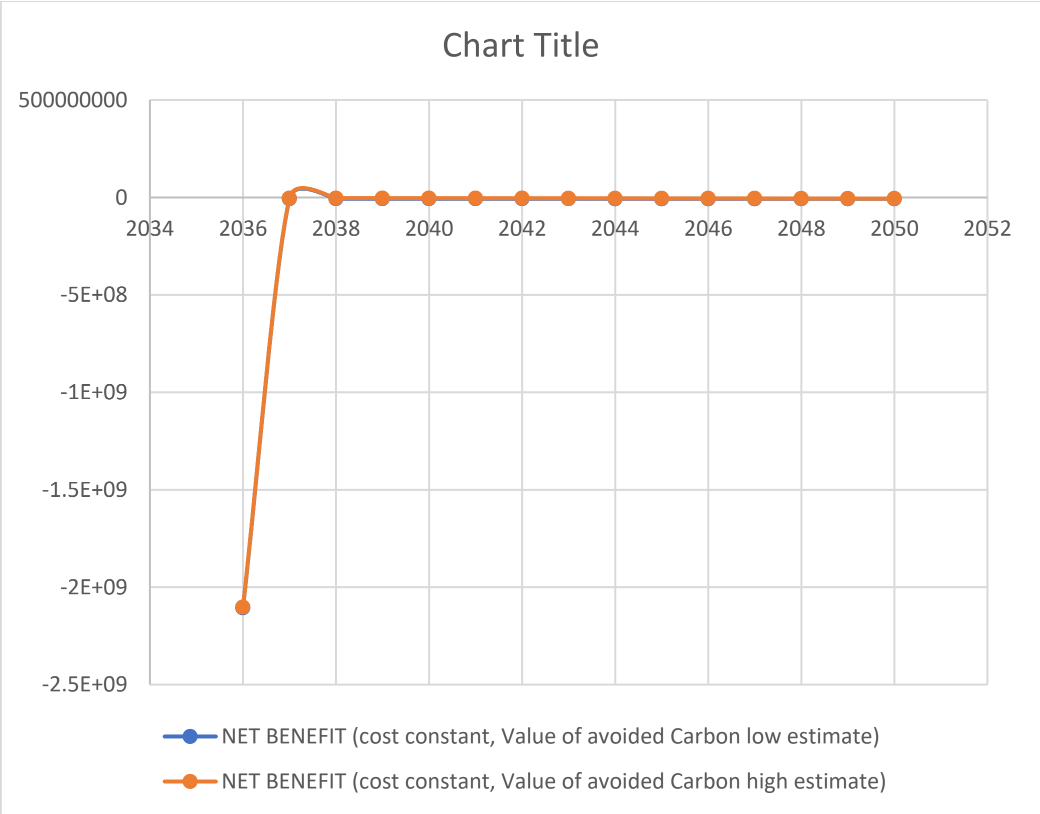


Figure 7 : Net Benefits due to electric vehicle for waste collection

Above figure indicates that net negative benefits are resulted from the action due to the high cost of the action. The economic analysis of the action has resulted in net present value as follows for different prices used. The following table provides details.

Table : Net present values of using Electric vehicle for waste collection under different prices of avoided carbon and cost escalations

Context	**Net present value (LKR) @ 10% discount rate**
Net benefit (cost constant, Value of avoided Carbon low estimate)	-1,959,271,804.33
Net benefit (cost constant, Value of avoided Carbon high estimate)	-1,940,537,516.89
Net benefit (cost 2% increase, Value of avoided Carbon low estimate)	-2,005,534,129.59
Net benefit (cost 2% increase, Value of avoided Carbon high estimate)	-1,986,799,842.15

Emission reduction action 3: Waste to energy plants

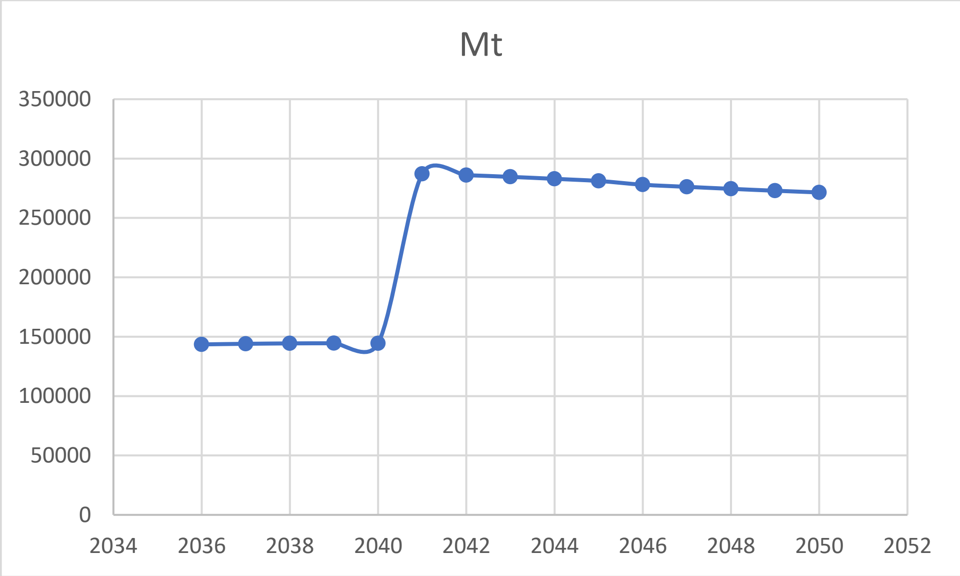


Figure 8 : Reduced emissions due to Waste to energy plants

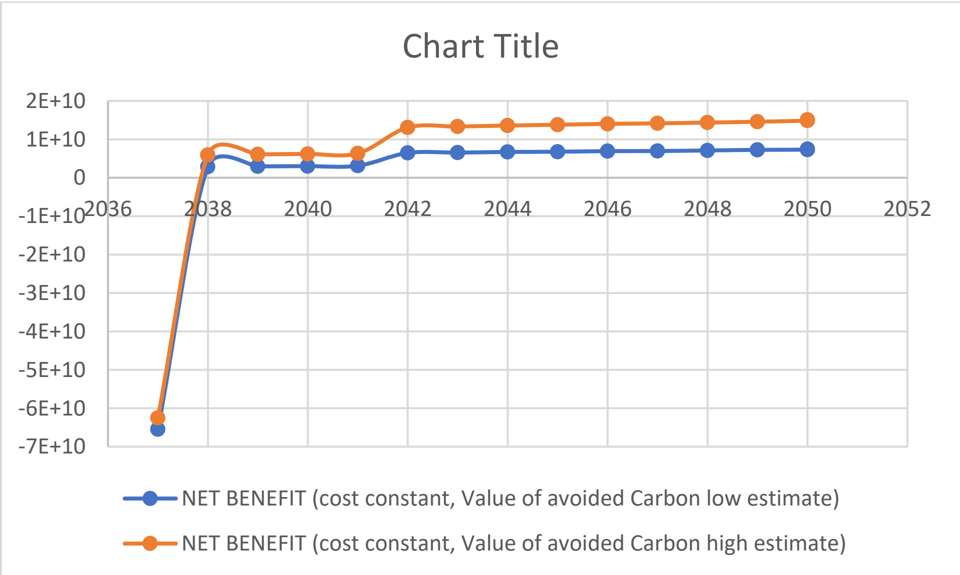


Figure 9 : Net Benefits due to Waste to energy plants

Above figure indicates that from 2038, there are net positive benefits. However, the economic analysis of the action has resulted in net present value only for high carbon prices. The following table provides details.

Table : Net present values of using waste to energy plants under different prices of avoided carbon and cost escalations

Context	Net present value (LKR) @ 10% discount rate
Net benefit (cost constant, Value of avoided Carbon low estimate)	-24,739,041,603.49
Net benefit (cost constant, Value of avoided Carbon high estimate)	13,887,404,121.78
Net benefit (cost 2% increase, Value of avoided Carbon low estimate)	-26,003,572,571.55
Net benefit (cost 2% increase, Value of avoided Carbon high estimate)	12,622,873,153.72

Emission reduction action 4: Sanitary landfill

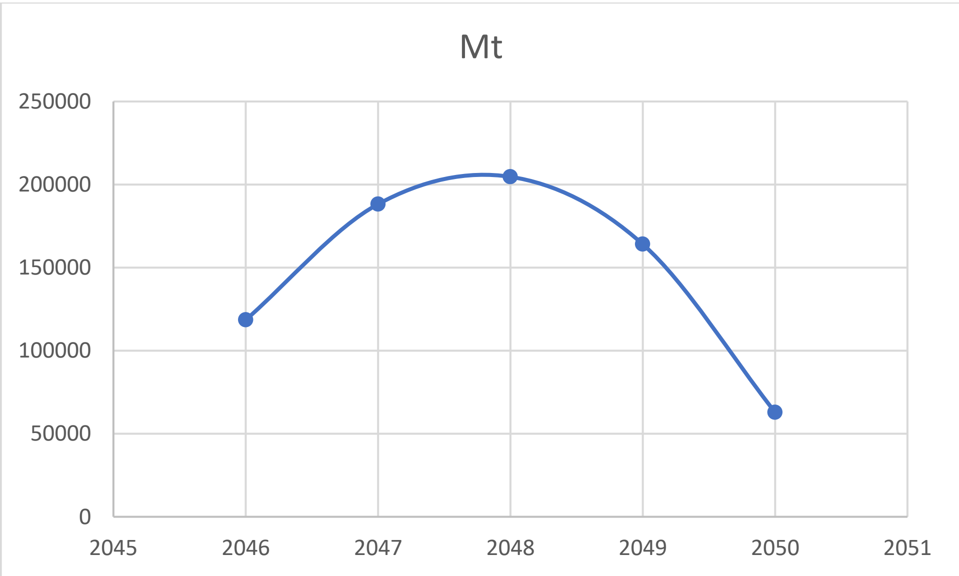


Figure 10 : Reduced emissions due to Sanitary landfill

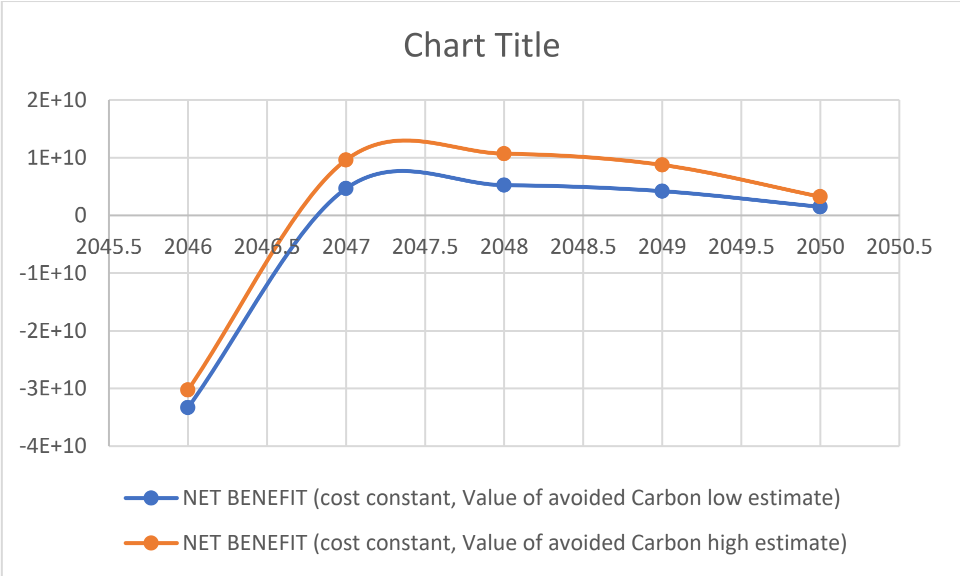


Figure 11 : Net Benefits due to Sanitary landfill

Above figure indicates that from 2047, there are net positive benefits. However, the economic analysis of the action has resulted in net negative present values. The following table provides details.

Table : Net present values of sanitary landfill action under different prices of avoided carbon and cost escalations

Context	**Net present value (LKR) @ 10% discount rate**
Net benefit (cost constant, Value of avoided Carbon low estimate)	-18,721,691,991.70
Net benefit (cost constant, Value of avoided Carbon high estimate)	-3,540,883,638.19
Net benefit (cost 2% increase, Value of avoided Carbon low estimate)	-19,399,266,201.12
Net benefit (cost 2% increase, Value of avoided Carbon high estimate)	-4,218,457,847.60

Sequestration action 1: Daily Cover for Open dump

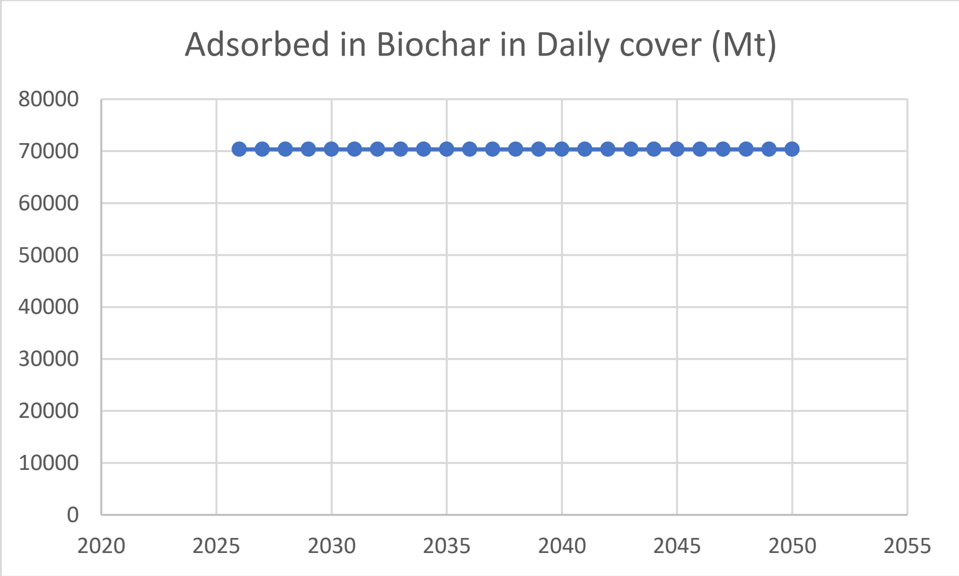


Figure 12: Reduced emissions due to daily cover using biochar

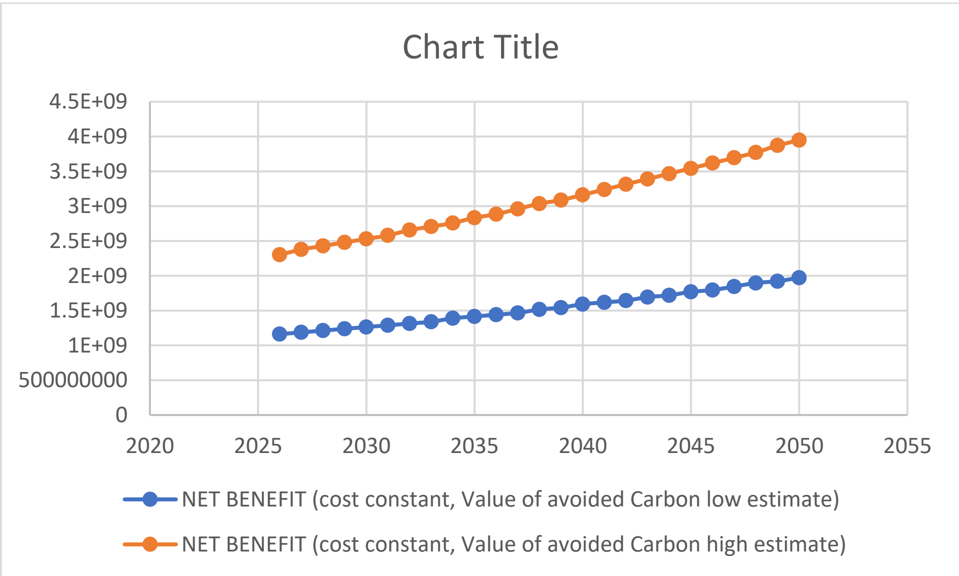


Figure 13: Net Benefits due to daily cover using biochar

Above figure indicates that the action has resulted in net positive benefit. The economic analysis of the action has resulted in net present value as follows for different prices used. The following table provides details.

Table : Net present values of using daily cover using biochar under different prices of avoided carbon and cost escalations

Context	**Net present value (LKR) @ 10% discount rate**
Net benefit (cost constant, Value of avoided Carbon low estimate)	12,523,805,993.20
Net benefit (cost constant, Value of avoided Carbon high estimate)	25,079,884,074.14
Net benefit (cost 2% increase, Value of avoided Carbon low estimate)	12,519,270,960.56
Net benefit (cost 2% increase, Value of avoided Carbon high estimate)	25,075,349,041.49

Sequestration action 2: Vertical Subsurface flow constructed wetland (VSSFCW)

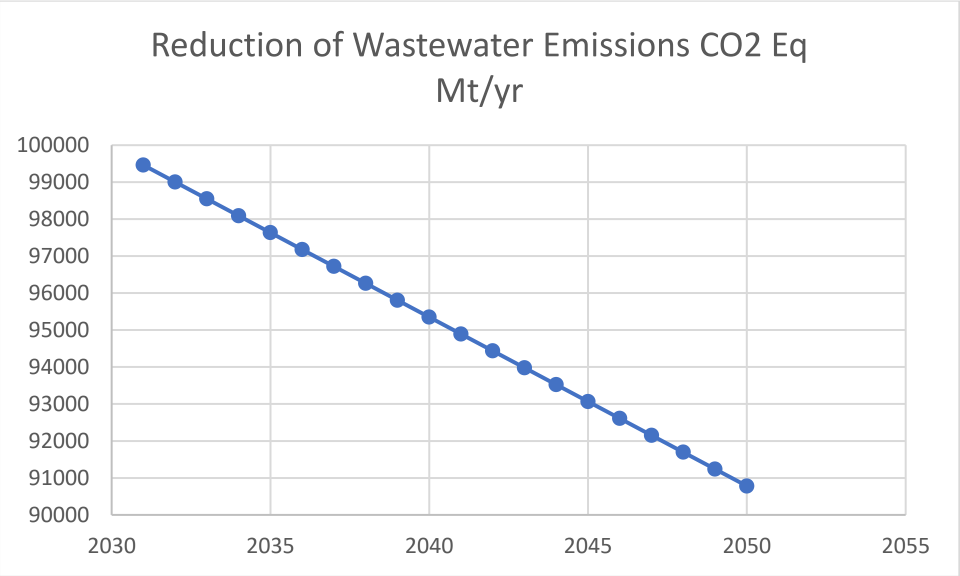


Figure 14: Reduced emissions due to Vertical Subsurface flow constructed wetland (VSSFCW)

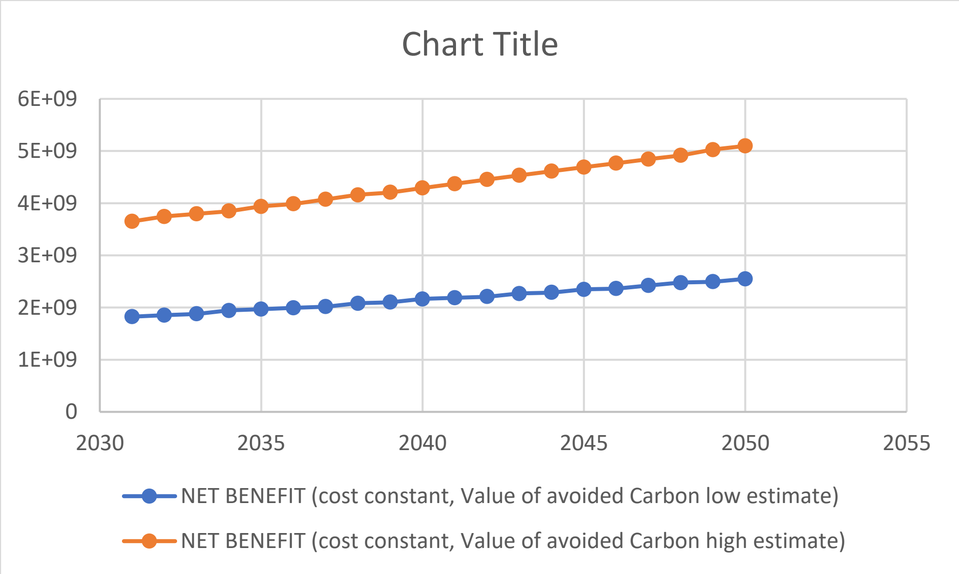


Figure 15 : Net Benefits due to Vertical Subsurface flow constructed wetland (VSSFCW)

Above figure indicates that the VSSFCW action has resulted net positive benefit. The economic analysis of the action has resulted in net present value as follows for different prices used. The following table provides details.

Table : Net present values of Vertical Subsurface flow constructed wetland under different prices of avoided carbon and cost escalations

Context	**Net present value (LKR) @ 10% discount rate**
Net benefit (cost constant, Value of avoided Carbon low estimate)	17,526,843,002.79
Net benefit (cost constant, Value of avoided Carbon high estimate)	35,118,949,434.14
Net benefit (cost 2% increase, Value of avoided Carbon low estimate)	17,526,773,785.74
Net benefit (cost 2% increase, Value of avoided Carbon high estimate)	35,118,880,217.09

Summary of the economic analysis of waste sector is provided in the following table.

Table: Net present values of proposed mitigation actions for waste sector

	Net Present Value (LKR) @ 10% discount rate	
	Value of avoided Carbon (lower estimate)	**Value of avoided Carbon (lower estimate)**
Emission reduction (ER) actions and sequestration enhancement (SE) actions		
ER action 1: Syngas recovery from open dump	-5,052,744.20	53,115,328.99
ER action 2: Electric vehicle for waste collection	-1,959,271,804.33	-1,940,537,516.89
ER action 3: Waste to energy plants	-24,739,041,603.49	13,887,404,121.78
ER action 4: Sanitary landfill	-18,721,691,991.70	-3,540,883,638.19
SE action 1: Daily Cover for Open dump	12,523,805,993.20	25,079,884,074.14
SE action 2: Vertical Subsurface flow constructed wetland (VSSFCW)	17,526,843,002.79	35,118,949,434.14
All 6 actions combined	4,346,928,810.96	25,805,688,533.22

Among the proposed actions of waste sector Daily Cover for Open dump and Vertical Subsurface flow constructed wetland (VSSFCW) have resulted in positive net present values. When all actions for waste sector are considered together, it has resulted in positive net present values.

4. Forestry sector

Net Carbon Sequestration in Forests, Trees Outside Forests and Mangroves in the Net Zero Scenario (tonnes /yr) is given in the following figure.

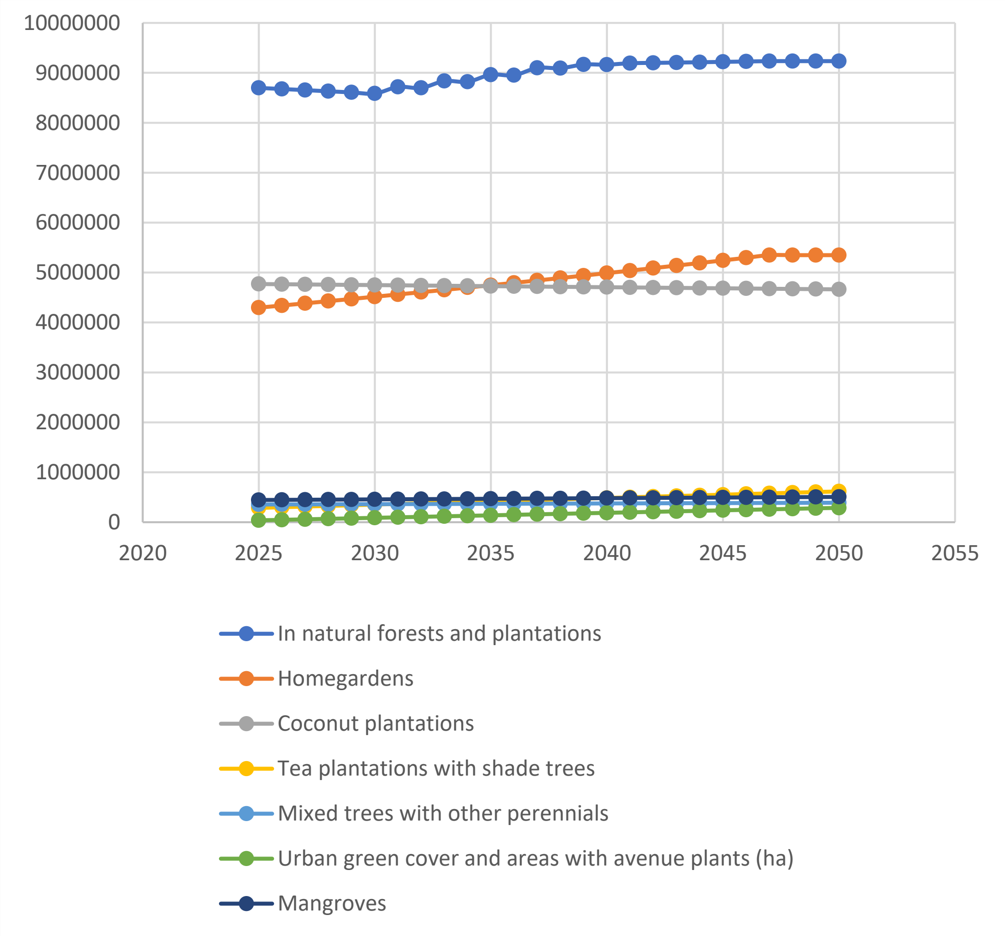


Figure 16: Net Carbon Sequestration in Forests, Trees Outside Forests and Mangroves in the Net Zero Scenario (tonnes /yr)

The following table provides Net Present Values for the forestry sector.

Table: Net present values of proposed mitigation actions for Forestry sector

Sector and Mitigation actions	**Net Present Value (LKR) @ 10% discount rate**	
	Value of avoided Carbon (lower estimate)	**Value of avoided Carbon (upper estimate)**
Forests in natural forests and plantations	$1,481,668,327,940.23	3,129,478,180,480
Trees Outside Forests		
Homegardens	816,056,745,585	1,656,563,163,232
Coconut plantations	469,289,070,006	1,637,038,422,127
Tea plantations with shade trees	70,930,596,918	141,838,967,699

Sector and Mitigation actions	Net Present Value (LKR) @ 10% discount rate	
	Value of avoided Carbon (lower estimate)	**Value of avoided Carbon (upper estimate)**
Mixed trees with other perennials	64,883,821,812	129,681,864,833
Urban green cover and areas with avenue plants	-56,994,596,077	43,041,161,765
Blue Carbon Ecosystems		
Mangroves	72,657,022,054.15	164,789,655,745
Total for all actions	2,832,663,961,588.63	6,302,663,521,836

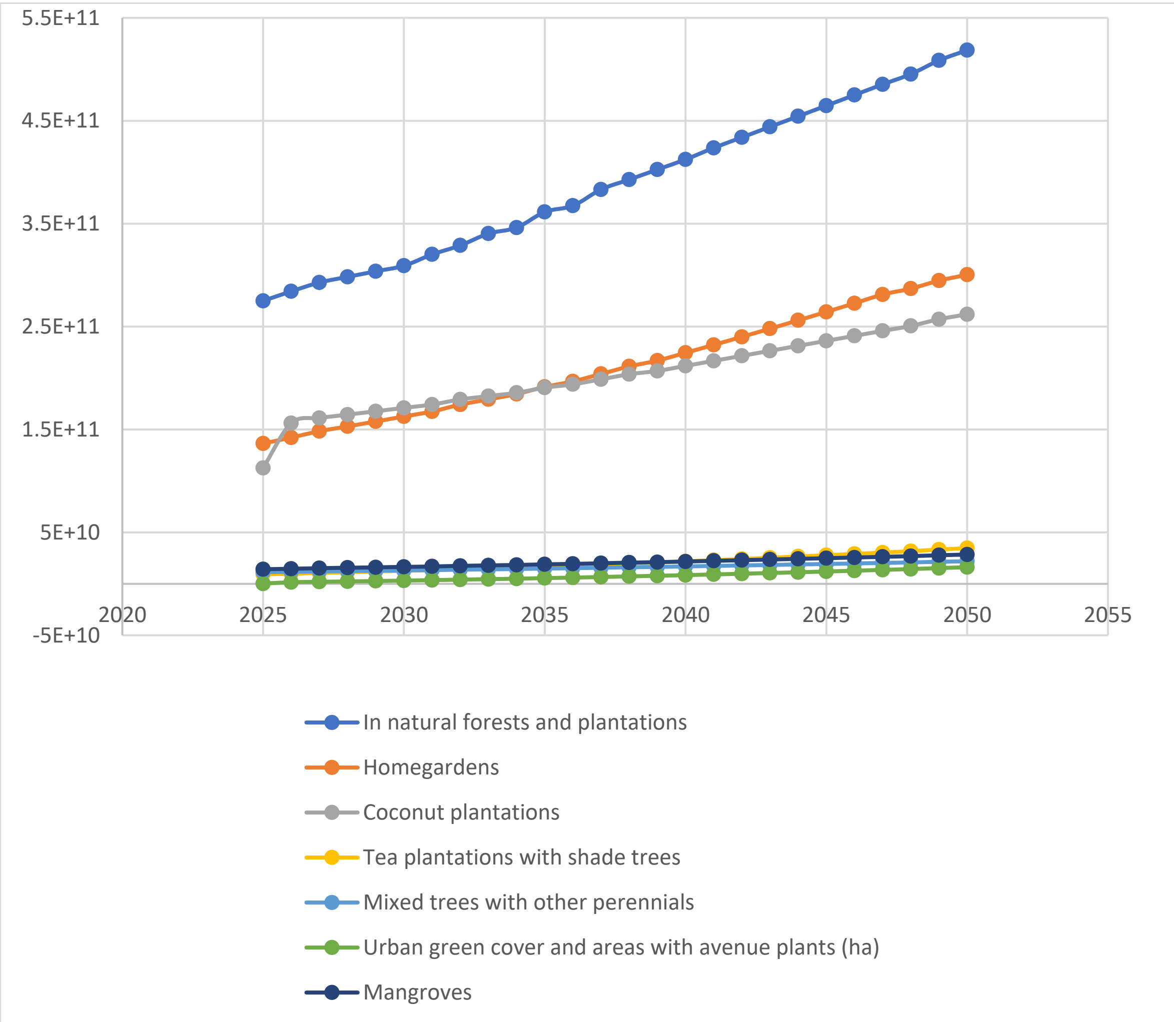


Figure 17: Net benefits of proposed mitigation actions for Forestry sector under upper estimate of carbon

Among the proposed actions of forestry sector, all actions have resulted in positive net present values except for urban green cover and areas with avenue plants under lower estimate of value of avoided carbon. When all actions for forestry sector are considered together, it has resulted in positive net present value of 2832 LKR billion under lower value of carbon and 6302 LKR billion under upper value of carbon. This analysis however has not taken into account variety of other benefits resulting from increasing forest cover including benefits due to variety of ecosystem services. There are variety of direct and indirect economic benefits associated with homegadens and mangrove forests. Benefits of increased extents of plantations will generate additional direct income.

5. Agriculture sector

The following figure illustrates the mitigated CO2 emissions due to the actions proposed by the sector.

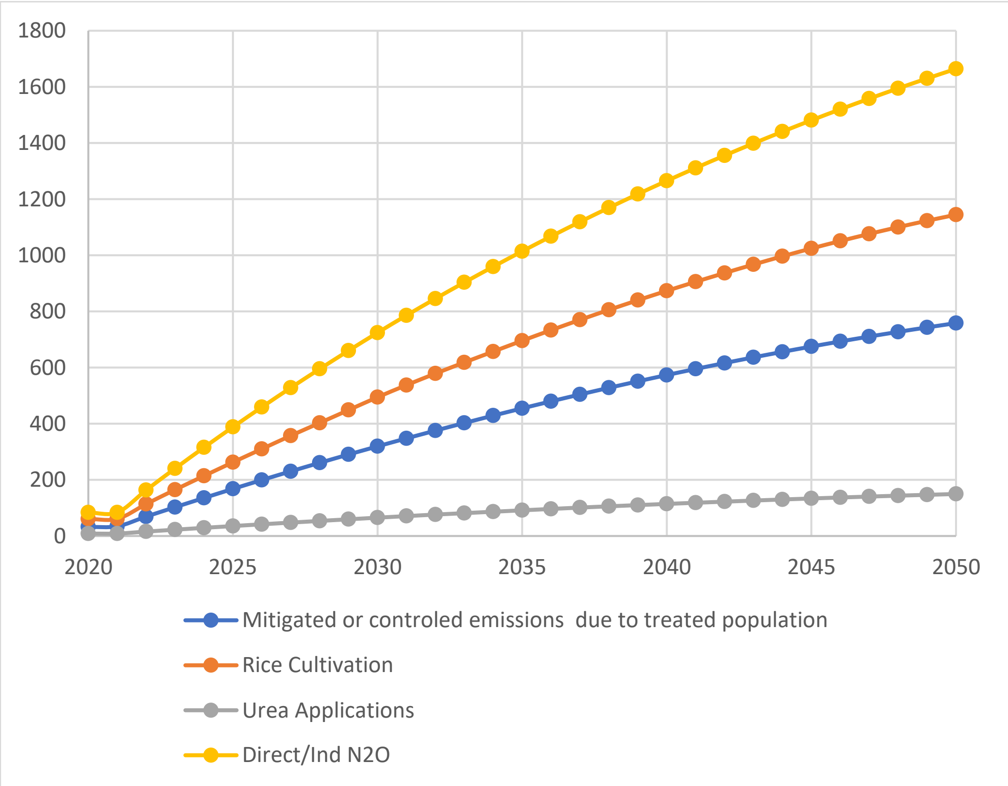


Figure 18: Mitigated CO2 emissions due to the actions proposed by the agriculture sector

The following table provides Net Present Values (NPV) for the Agriculture sector.

Table: Net present values of proposed mitigation actions for agriculture sector

Mitigation actions	Net Present Value (LKR) @ 10% discount rate	
	Value of avoided Carbon (lower estimate)	**Value of avoided Carbon (upper estimate)**
Emission reduction treatment for neat cattle (both imported and local)	-198,931,253,860.50	-198,882,959,958.46
All actions in agriculture sector including actions to mitigate emissions related to Rice Cultivation, Urea Applications and Direct/Indirect N2O	-198,738,491,541.80	-198,497,416,260.95

The lower emission reductions and higher costs associated with agricultural actions have resulted in large negative net present values. The above analysis assumed actions to mitigate emissions related to Rice Cultivation, Urea Applications and Direct/Indirect N2O as costless.

Summary

The following table provides summary for all sectors, the present values of all costs and benefits for each sector.

Table: 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: 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 positive net present value of 1000 LKR billion indicating the viability of the remaining sectors under upper estimate of the value of carbon.

It is important to estimate a proper price for the carbon savings to see how the actions 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 in order to finance the proposed mitigation measures from international sources.