KINGDOM OF CAMBODIA
NATION-RELIGION-KING

# Long-Term Strategy for Carbon Neutrality

December
2021

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# Foreword

The Kingdom of Cambodia, as a country vulnerable to the impacts of climate change, understands the urgency of ambitious climate action. Although Cambodia bears very little responsibility for the historical and current climate crisis, we have consistently responded to international calls for action on climate change and contributed to the efforts, in line with our capacities and responsibilities under the United Nations Framework Convention on Climate Change.

As announced by **Samdech Akka Moha Sena Padei Techo Hun Sen**, Prime Minister of the Kingdom of Cambodia, during the 2020 United Nations Climate Ambition Summit, this "Long-Term Strategy for Carbon Neutrality (LTS4CN)" is yet another testament to our consistent, strong commitment and political will to address climate change.

We are proud to be among the very first members of the Least Developed Country group to submit this long-term strategy. This is a highly significant step for a developing country like Cambodia. This also reflects leading by example on climate change action on the part of Cambodia, a strong supporter of multilateral action on climate change.

This LTS4CN essentially aims to serve as a roadmap or vision document based on a comprehensive analysis and modelling of all relevant economic sectors, and it looks several decades ahead. It outlines priority mitigation actions for each sector to achieve the country's goal of a carbon neutral economy in 2050. The strategy largely builds on existing commitments of the Royal Government and proposes a trajectory consistent with the Updated Nationally Determined Contribution. It takes into consideration the balance between emissions reductions, economic growth, social justice, and climate resilience. Economic analysis shows that the investments to be made under this strategy have the potential to create 449,000 additional jobs, and deliver an additional 2.8% of annual GDP growth by 2050 for Cambodia. We can achieve carbon neutrality by 2050 through continued efforts to address the forest sustainability and land use; decarbonize our power sector and pursue higher energy efficiency; as well as promote low-carbon agriculture, industrial processes, and waste management.

The vision set out in this document will be regularly updated and may be amended as needed to reflect any evolving trends or unforeseen events. It provides an overall policy direction, while the exact commitments and programmes of the Royal Government will continue to be articulated in our Five-Year National Strategic Development Plans and corresponding sector plans.

We believe that this LTS4CN will help Cambodia to achieve carbon neutrality, which will be our major contribution to the sustainable development in Cambodia and the world.

It is worth acknowledging here our inter-ministerial team who diligently took up the challenge to develop this LTS4CN through a year-long process of intensive discussion and consultations among international and national experts, concerned ministries, and key relevant stakeholders.

Our acknowledgement also goes to all our valued partners who have contributed to the development of this important document, including, but not limited to, the Cambodia Climate Change Alliance programme (funded by the European Union, Sweden, and the United Nations Development Programme), the United Kingdom, the World Bank, the Food and Agriculture Organization of the United Nations, Global Green Growth Institute, and Agence Française de Développement.

It is imperative that the implementation of this LTS4CN requires strong cooperation and supports, and we look forward to working with all stakeholders to make this long-term vision a reality.

**Say Samal**

Chair of the National Council for Sustainable Development

Minister of Environment

# Abbreviations

| | |
|---|---|
| **BAU** | Business as Usual |
| **CCGT** | Combined-Cycle Gas Turbine |
| **CEGIM** | Climate Economic Growth Impact Model |
| **CNG** | Compressed Natural Gas |
| **FOLU** | Forestry and Other Land Use |
| **GDP** | Gross Domestic Product |
| **GHG** | Greenhouse Gas |
| **ILO** | International Labour Organization |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **IPPU** | Industrial Processes and Product Use |
| **LTS4CN** | Long-Term Strategy for Carbon Neutrality |
| **LNG** | Liquified Natural Gas |
| **MAC** | Marginal Abatement Cost |
| **MRV** | Measurement, Reporting and Verification |
| **$MtCO_2e$** | Megatons of Carbon Dioxide Equivalent |
| **NDC** | Nationally Determined Contribution |
| **REDD+** | Reducing Emissions from Deforestation and Forest Degradation, fostering conservation and sustainable management of forests, and enhancing forest carbon stocks |
| **SAM** | Social Accounting Matrix |
| **$tCO_2e$** | Tons of Carbon Dioxide Equivalent |

# Executive Summary

**An innovative visioning exercise for Cambodia**

By presenting this Long-Term Strategy for Carbon Neutrality (LTS4CN)[1], Cambodia demonstrates her commitment to the Paris Agreement on Climate Change and presents a policy scenario to realize a vision of a carbon neutral and resilient society within the next 30 years. The LTS4CN is a new type of policy tool for Cambodia. As a visioning exercise, it is not meant to replace or supersede existing national and sectoral strategies of the Government but rather to guide future policy and investment decisions by all concerned stakeholders.

The LTS4CN will possibly be reviewed every five years, in line with the framework for updating Nationally Determined Contributions (NDCs) under the Paris Agreement. This will provide an opportunity to refresh the LTS4CN and reflect the latest trends in policy, technology, and financing as well as any unforeseen external events.

Developing the strategy was a collective effort that included contributions from relevant ministries and agencies as well as technical experts. A two-stage greenhouse gas (GHG) emissions modelling approach applied sector models to the agriculture, forestry and other land use (FOLU), industrial processes and product use (IPPU), energy, and waste sectors. A combined pathway model indicated the socioeconomic impacts of proposed measures.

The process started with defining relevant existing policy targets and action plans in national and sectoral strategies as well as in the Updated NDC issued in 2020. An intensive round of consultations led to the identification of priority mitigation actions for each sector. Different scenarios were developed to explore how these actions can reduce emissions and help achieve carbon neutrality, compared to business as usual (BAU). An economic modelling estimated the socioeconomic costs using the marginal abatement cost model. Adaptation benefits were elaborated for suggested mitigation actions.

**A credible scenario for carbon neutrality by 2050**

The LTS4CN modelling suggests that Cambodia could achieve carbon neutrality in 2050 with the FOLU sector providing a total carbon sink of 50 megatons of carbon dioxide equivalent ($MtCO_2e$). The energy sector is expected to be the highest emitter in 2050 at 28 $MtCO_2e$, followed by the agriculture sector at 19 $MtCO_2e$. The waste and IPPU sectors are projected to emit 1.6 and 1.2 $MtCO_2e$, respectively (Table 1).

[1] Carbon neutrality for this strategy is considered as Net Zero Greenhouse Gas Emissions.

*Table 1: GHG emissions projection by sector in 2050, BAU and LTS4CN scenarios*

| Sector | BAU scenario, $MtCO_2e$ | Emissions reduction in LTS4CN scenario, $MtCO_2e$ | Emissions balance in LTS4CN scenario, $MtCO_2e$ |
|---|---|---|---|
| **Agriculture** | 34.9 | -15.6 | 19.3 |
| **Energy** | 82.7 | -54.3 | 28.2 |
| **FOLU** | 21.2 | -71.4 | (-50.2) |
| **IPPU** | 10.7 | -9.1 | 1.6 |
| **Waste** | 6.5 | -5.3 | 1.2 |
| **Total** | 156.0 | 155.6 | 0,3 |

*The FOLU sector uses the national forest definition and soils have been included into the calculations.

The LTS4CN proposes a trajectory for decarbonization that is largely aligned with the updated NDC trajectory. It incorporates some carbon sinks not previously considered in the NDC, however, including an updated sink factor for forests remaining forests (in line with the second Forest Reference Level Report), and for plantations and forest soils. This leads to a lower estimate of total GHG emissions, at around 35 $MtCO_2e$ less in 2020 compared to the NDC.

Cambodia's vision for carbon neutrality is largely founded on the continued implementation of existing commitments in the FOLU sector. Execution of the REDD+ Investment Plan[2] will drive reduced rates of deforestation as well as an expansion of afforestation and reforestation activities. The FOLU sector is expected to provide a significant carbon sink leaving room for other sectors to incrementally transition towards carbon neutrality.

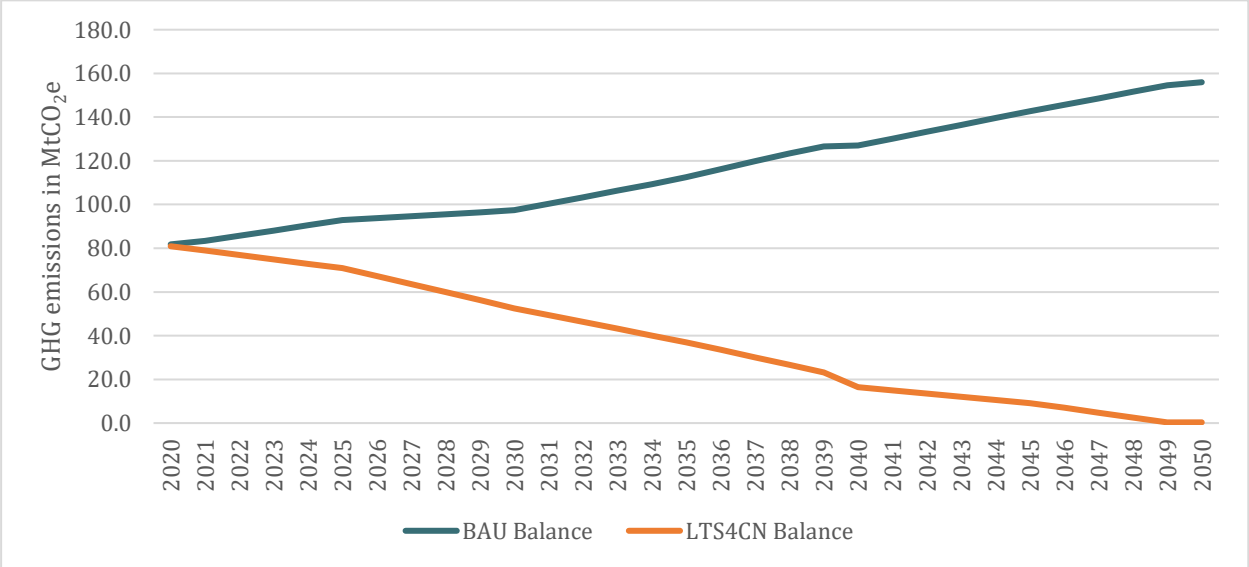


*Figure 1: GHG emission projections, BAU and LTS4CN scenarios*

During the first decade of the strategy, emissions reductions are achieved in the FOLU sector by starting implementation of the REDD+ Investment Plan. Once it is fully financed, it is expected to reduce the deforestation rate by 50 percent in 2030 compared to the REDD+ baseline specified in the updated NDC (reduce 50percent of historical emission). From 2030 onwards, reforestation and afforestation efforts will continue with a raised level of ambition to ensure that the carbon sink from

[2] REDD+ refers to reducing emissions from deforestation and forest degradation, fostering conservation and sustainable management of forests, and enhancing forest carbon stocks.

forests continues to grow. The FOLU sector is expected to be carbon neutral from 2031. Afforestation and reforestation efforts will be compatible with growth in the agricultural sector because of expected gains in productivity and climate resilience. Deforestation is assumed to stop by 2045, with the FOLU sector becoming both resilient and sustainable, transformed by agroforestry and reforestation as two dynamic mitigation actions. Land dedicated to sustainable plantations and agroforestry is assumed to constantly increase to reach 1.6 million hectares under afforestation and reforestation mitigation actions and 1.1 million hectares of native forest restoration.[3] These combined actions will result in a carbon sink of 50 $MtCO_2e$ in 2050.

In the energy sector, emissions reductions until 2030 come from energy efficiency and conservation through the implementation of the National Energy Efficiency Policy[4] in buildings, industry, and public services. This will limit growth in energy demand even as demand for energy services rises rapidly. Additionally, policies will be developed and put into place to incentivize switching to electricity for cooking and passenger vehicles, and to coal alternatives in the industrial sector. Major long-term infrastructural changes in the energy sector will be studied and prepared in this first decade. After 2030, energy sector emissions reductions will come from more stringent energy efficiency standards and continued fuel switching to low-carbon sources. Initial steps to decarbonize the electricity supply will be taken, with some investments in renewable energy and gas. With natural gas used as a transition fuel in the power sector, investments in infrastructure for imports, storage and transportation will be necessary. In the last decade of the LTS4CN scenario, between 2040 and 2050, the power sector will start a deeper decarbonization journey by adding more renewable energy in the generation mix, reaching a share of 35 percent in 2050. Within the renewable energy share, 12 percent is assumed to come from solar. Investments in grid modernization, flexibility and storage will be required during this transition.

In the transportation sector, urban public transportation will become more widespread and electric vehicle penetration will grow in the passenger vehicle fleet. Investments in rail development will start after 2030. Emissions will be also reduced by more moderate use of electric vehicles, increased fuel efficiency for internal combustion engine vehicles and higher penetration of compressed natural gas (CNG) for interregional buses and for trucks. Under the LTS4CN scenario, 70 percent of motorcycles and 40 percent of cars and urban buses are expected to be electric vehicles by 2050.

The waste sector will achieve half of its emission savings in the first decade through mitigation measures in solid waste disposal, for example, by diverting organic waste from landfills or introducing the effective management of landfill gas. Other important mitigation measures are linked to reducing open burning and domestic wastewater. A small but increasing share of emissions savings will be achieved through introducing good practices in the biological treatment of solid waste. In 2050, the waste sector is expected to realize nationwide waste collection coverage of 85 percent and will be almost fully decarbonized. The recycling rate will increase to 35 percent; 50 percent of organic waste will be composted or treated. Most urban dwellings will have access to proper wastewater treatment. And the principle of reduce, reuse, and recycle will be mainstreamed into the national development agenda, including through environmental, social and economic plans, policies, strategies, and programmes.

Mitigation actions in the agriculture sector are expected to be implemented gradually over the 30-year period. Major reductions will be achieved by reducing methane-intensive rice and livestock production, and promoting composting and producing biogas in livestock management, organic fertilizer, and deep fertilizer technology.

Major mitigation actions for the IPPU sector will start in the first decade of the LTS4CN scenario, with emissions projected to peak in the early 2030s before dropping steeply until 2040. Between 2040 and 2050, emissions will fall gradually. Key mitigation actions in the sector are clinker substitution

[3] A total of 2.7 million hectares is aligned with the target in the REDD+ Investment Plan.
[4] Prepared by the Ministry of Mines and Energy for 2021 to 2030.

and carbon capture and storage in cement production, recycling of aggregate concrete, increased use of refrigerants with low global warming potential and regular inspection of refrigeration and air-conditioning equipment as well as recovery of spent refrigerants.

**The LTS4CN pathway delivers net economic benefits reaching 2.8 percent of GDP by 2050**

Economic analysis of the LTS4CN suggests net economic benefits for the public and private sectors, in addition to adaptation and wider social and environmental benefits. These net benefits start from the first year of LTS4CN implementation and reach more than US $4.2 billion in 2050, over 2.8 percent of projected GDP. Wider social and environmental benefits including adaptation co-benefits from LTS4CN actions are estimated to be worth more than the economic benefits, at nearly $7 billion in 2050.

By 2050, the private sector is projected to invest nearly $1.4 billion each year, mostly in energy, transportation, and the forestry sectors, with some significant investment in the IPPU sector. Benefits in terms of private sector operating expenses are over six times the investment and come from a wide range of actions. Significant benefits come from energy efficiency ($3.4 billion), vehicle electrification ($1.1 billion) and rail and freight haulage ($1.1 billion). These are reduced by $800 million in opportunity costs from protecting forests from conversion to agriculture. Public capital expenditures are relatively small, with some ongoing investment in renewable energy, buses, trains, and forestry, in line with the REDD+ Implementation Plan. There are significant ongoing public operating expenses, dominated by rail and haulage ($500 million) and the loss of a fuel tax from the electrification of vehicles ($200 million). These costs are offset by operating profits from renewable energy. The net contribution of agriculture, waste, and IPPU sectors is small.

Implementing the LTS4CN will require substantial public investment over 30 years (Figure 2). A proposed public financing plan suggests devoting 1 percent of new public borrowing to the LTS4CN and making a small shift to divert 3 percent of public spending on economic services to LTS4CN actions. These two measures provide 40-50 percent of financing needs. The financing plan assumes that pricing policies and taxation reform in the transportation sector will be introduced gradually and cover 90 percent of transportation sector costs by 2050.

The financing plan also assumes that international climate finance will meet the remainder of public finance needs. This will cover major investment in public transportation and rail freight, support in the forestry sector, and financing for carbon capture and storage, and grid flexibility. International climate finance is essential for Cambodia to implement the LTS4CN scenario.

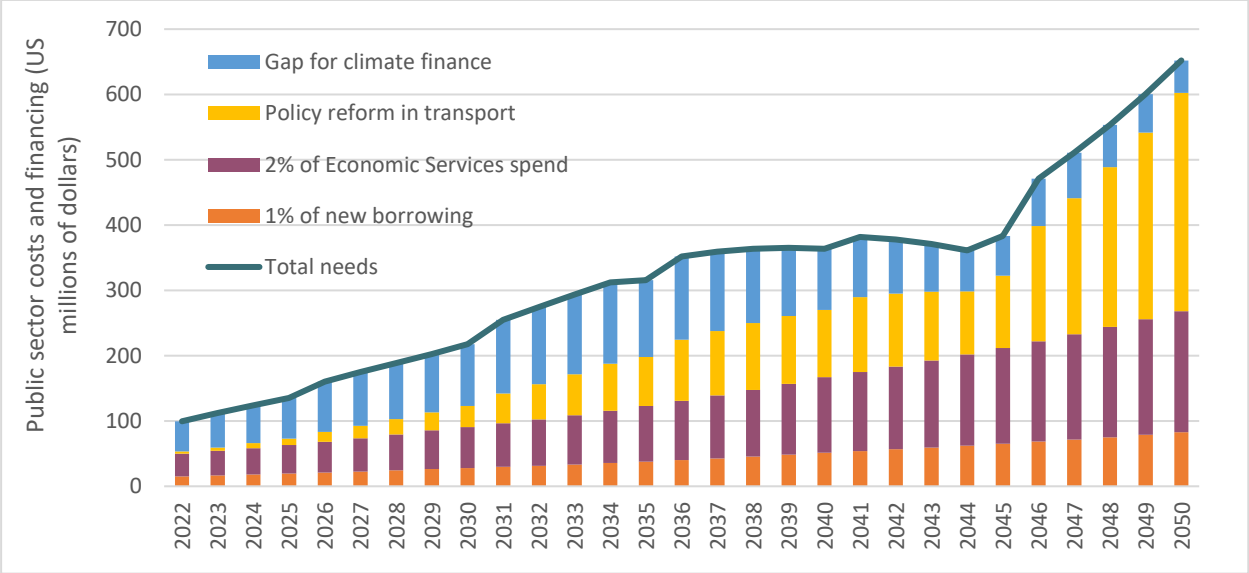


*Figure 2: Public financing needs and financing plan*

Achieving Cambodia's LTS4CN scenario is an ambitious but feasible goal. Realizing it depends on a comprehensive enabling environment, sufficient access to technology and climate financing, and extensive capacity building, and education.

With reducing emissions to net zero by 2050 critical to meeting the Paris Agreement goal of keeping the global average temperature increase below 1.5°C, Cambodia is committed to leading the way. The LTS4CN is an important starting point in providing guidance on how it can reach carbon neutrality by 2050.

| | |
|---|---|
|  **Agriculture** | • **Less methane-intensive rice cultivars**<br>• **Direct seeding practices**<br>• **Alternate wetting and drying practices**<br>• **Promotion of organic fertilizer and deep fertilizer technology**<br>• **Feed additives for cattle**<br>• **Improved fodder management**<br>• **Introduction of composting technology** |
|  **Forestry and other land uses** | • **Reducing the deforestation rate by 50 percent in 2030**<br>• **Stopping deforestation by 2045**<br>• **Afforestation, improved forest management and forest restoration**<br>• **Agroforestry and commercial tree plantation**<br>• **Full implementation of the REDD+ Investment Plan by 2050** |
|  **Energy** | • **No new coal generation capacity beyond already committed projects**<br>• **Use of natural gas as a dispatchable transition fuel**<br>• **Investments in liquified natural gas (LNG) import, storage and infrastructure**<br>• **Increase in solar, hydro, biomass and other renewables to 35 percent of the generation mix by 2050, of which 12 percent is from solar**<br>• **Investments in grid modernization, flexibility and storage Energy efficiency measures in buildings and industry**<br>• **Fuel switching to electricity for cooking**<br>• **Substitution of coal in the industrial and power sector** |
|  **Transportation** | • **More use of public transportation – 30 percent modal share in urban areas by 2050**<br>• **Moderate penetration of electric vehicles – 70 percent for motorcycles and 40 percent for cars and urban buses by 2050**<br>• **Increased fuel efficiency for internal combustion engine vehicles**<br>• **Rail for freight and passengers**<br>• **CNG penetration of 80 percent for interregional buses and 80 percent for trucks until 2050** |
|  **Industrial processes and product use** | • **Clinker substitution in cement production**<br>• **Carbon capture and storage for cement kilns**<br>• **Use of recycled aggregate concrete**<br>• **Increasing use of refrigerants with low global warming potential**<br>• **Regular inspection of refrigeration and air-conditioning equipment and recovery of spent refrigerants** |
|  **Waste** | • **Reducing open burning by expanding waste collection coverage to 85 percent in 2050**<br>• **Implementing a reduce, reuse, and recycle strategy**<br>• **Landfill gas management**<br>• **Organic composting**<br>• **Anaerobic digestion and wastewater treatment** |

*Figure 3: Summary of key mitigation actions by sector*

# 1. Introduction and Background

## 1.1. Global and local context of climate change

Science has made it clear that the Earth's climate is changing, in every region and across the global climate system. Most of these changes are unprecedented. According to the latest report from the Intergovernmental Panel on Climate Change (IPCC), climate action in the next decades is crucial to limit global warming. Staying below a temperature rise of 1.5°C or even 2°C will be nearly impossible if immediate, rapid and large-scale reductions in GHG emissions do not take place.[5] Improved observational data sets to assess historical warming and better scientific understanding of the response of the climate system have affirmed that human activities are responsible for the majority of global warming since 1850.

The Royal Government of Cambodia is committed to combating climate change and accelerating the transition to a climate-resilient, low-carbon, sustainable mode of development. Cambodia has been a party to the United Nations Framework Convention on Climate Change since 1996, the Kyoto Protocol since 2002, and the Paris Climate Agreement since 2017. Accordingly, the country submitted her first NDC in 2015 and the Updated NDC in 2020, highlighting ambitious targets to reduce emissions and strengthen adaptive capacity in line with Cambodia's national policies and strategies.

In the Updated NDC, Cambodia aims to reduce emissions by around 42 percent from 155 MtCO2e under BAU to 90.5 $MtCO_2e$ by 2030.[6] The first national Biennial Update Report was submitted in 2020, which includes emissions from 1994 to 2016. Total emissions in 2016 reached 163.6 $MtCO_2e$. The FOLU sector is the largest source of emissions in Cambodia.[7]

## 1.2. Developing Cambodia's long-term strategy

Development of the Long-Term Strategy for Carbon Neutrality (LTS4CN) concluded in 2021. It provides a detailed, evidence-driven guide to help Cambodia take long-term climate actions aligned with the Paris Agreement commitment to limiting global warming to 1.5°C. It includes institutional arrangements for long-term planning, development of a monitoring and evaluation framework, and analysis of financial options and socioeconomic impacts of selected priority actions.

Developing the LTS4CN included planning (Phase 1) and strategy development (Phase 2). The planning phase encompassed a literature review of key documentation and data sets and a vision-setting exercise based on desk research. The collection of baseline emissions information in five key sectors, namely FOLU, energy, agriculture, IPPU, and waste, was accompanied by an exploration of decarbonization pathways used or proposed in Cambodia so far. Phase 1 involved the development of a plan for the strategy development.

The outcomes of Phase 1 were consistent with a vision of reaching carbon neutrality by 2050 through upscaling existing mitigation activities and adding new activities. The study concluded that the main contributors to emissions in Cambodia are the FOLU, agriculture, and energy sectors. Reaching net zero by 2050, therefore, requires more focus on decarbonizing these sectors. In the FOLU sector, the main driver of emissions is the expansion of industrial agriculture, while in agriculture, a key source

[5] IPCC, 2021, Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.
[6] General Secretariat of the National Council for Sustainable Development, 2020, Cambodia's Updated Nationally Determined Contribution. Phnom Penh.
[7] General Secretariat of the National Council for Sustainable Development, 2020, First Biennial Update Report of the Kingdom of Cambodia. Phnom Penh.

of emissions is rice cultivation. Energy sector emissions are largely determined by the power mix, road transportation and the level of vehicle electrification.[8]

In Phase 2, all key stakeholders, under the leadership of the National Council for Sustainable Development, contributed to strategy development as illustrated in Figure 4.

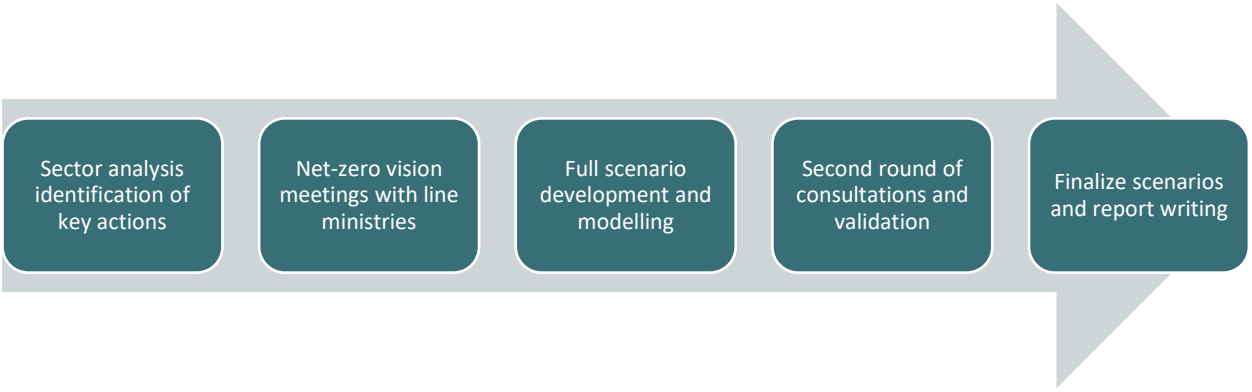


*Figure 4: Overall methodology for Phase 2 of developing the LTS4CN*

The Department of Climate Change of the General Secretariat of the National Council for Sustainable Development/Ministry of Environment and Cambodia Climate Change Alliance Phase 3 coordinated the development of the LTS4CN with support from development partners such as the United Nations Development Programme, Agence Française de Développement, Global Green Growth Institute, the Food and Agriculture Organization of the United Nations, Sweden, the United Kingdom, the European Union, and the World Bank.

A two-stage GHG emissions modelling exercise was employed, consisting of sector models for the agriculture, FOLU, IPPU, energy, and waste sectors, and a combined pathway model including a socioeconomic cost and benefit analysis. Intensive consultation with all relevant stakeholders from line ministries and other key institutions discussed priority mitigation actions and validated data, assumptions, and approaches. This ensured that suggested LTS4CN actions would be feasible and aligned with Cambodia's development priorities and at the same time targeted to the goal of carbon neutrality by 2050.

[8] Carbon Trust, 2021, A Long-Term Low Emissions Development Strategy (LT-LEDS) for Cambodia: Literature Review and Vision-Setting Report.

# 2. Cambodia's Vision for Carbon Neutrality

## 2.1. LTS4CN objectives and scenarios

The LTS4CN outlines a vision of a carbon neutral economy and provides long-term policy direction on how to reduce emissions in the next few decades. The overall goal of the strategy is to describe a pathway towards a country-wide carbon neutral economy by 2050.

### 2.1.1. The BAU scenario

Summarizing findings from sector analysis and modelling, under a BAU scenario, emissions are expected to increase at an annual rate of 1.9 percent up to 156 $MtCO_2e$. Figure 5 illustrates this emissions pathway. The FOLU sector has the highest share of total emissions, at 63percent in the base year of 2016. In 2050, 53 percent of total emissions is expected to come from the energy sector, followed by agriculture at 22 percent and FOLU at 14 percent. The smallest emitters are estimated to be the IPPU and waste sectors, with shares of 7 percent and 4 percent, respectively. The BAU scenario for the LTS4CN differs from the NDC BAU scenario primarily because additional carbon sinks have been incorporated in the analysis. The carbon sink factor for forests remaining forests has been aligned with the second Forest Reference Level Report recently submitted by Cambodia, and the carbon sink from forest soils has been added along with the sink from plantations included in the national forest definition.

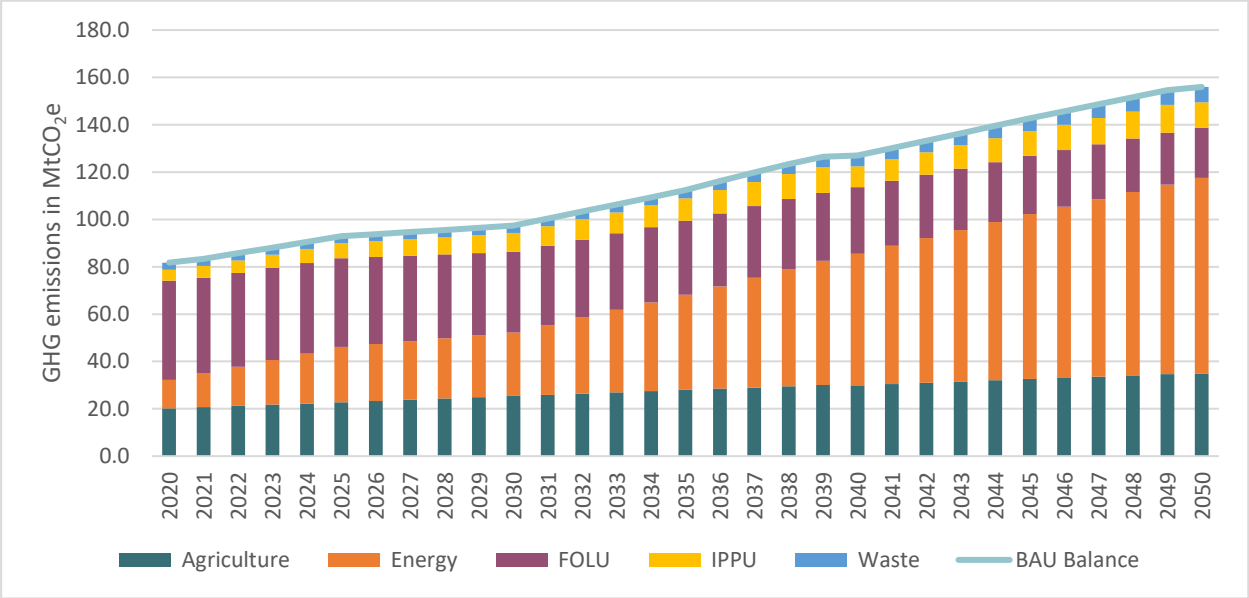


*Figure 5: GHG emissions projections in the BAU scenario by sector*

In the agriculture sector, rice cultivation, livestock management (enteric fermentation and manure management), nitrous oxide emissions from managed soils and fertilizer are the main contributors to emissions. Total emissions in the agriculture sector in the base year of 2016, amounted to 18 $MtCO_2e$. Emissions are estimated to almost double to 35 $MtCO_2e$ in 2050 assuming current trends continue and no major mitigation actions occur. The main drivers of the agriculture sector are population and economic growth, which lead to increased rice and meat production and consumption.

The energy sector was responsible for roughly 8 $MtCO_2e$ in 2016. It is the third largest emitting sector after FOLU and agriculture. Emissions are expected to grow exponentially, however, up to 83 $MtCO_2e$ under the BAU scenario by 2050, driven by population and economic growth leading to increased

energy demand. As the BAU scenario follows a conventional, primarily fossil fuel-based and emissions-intensive development path, emissions are expected to increase by a factor of 10.

The FOLU sector was responsible for 51 $MtCO_2e$ of emissions in 2016, the largest share of emissions in Cambodia. Deforestation is the major cause of emissions. Under the BAU scenario, emissions would decrease to 21 $MtCO_2e$ by 2050, with an annual decline by 2.6 percent between 2016 and 2050.

The waste sector is the second smallest emitter at 2.8 $MtCO_2e$ in 2016. Under BAU conditions, emissions are expected to grow to up to 6.5 $MtCO_2e$ by 2050, which includes emissions from solid waste disposal, biological treatment, burning, and wastewater.

In the IPPU sector, the mineral industry (cement and glass), pulp and paper, lubricants, substitutes for ozone-depleting substances (refrigeration and air conditioning, and fire protection) as well as the food and beverage industry are the main contributors to emissions. Emissions totaled 1.8 $MtCO_2e$ in 2016, mainly from the cement industry (1.4 $MtCO_2e$, 74 percent) and refrigeration and air conditioning (0.4 $MtCO_2e$, 21 percent). According to BAU projections, emissions in 2050 is expected to increase to 11 $MtCO_2e$, with 55 percent from the cement industry and 39 percent from refrigeration and air conditioning.

### 2.1.2. The LTS4CN scenario

Reaching carbon neutrality requires both reducing sources of emissions, such as the combustion of fossil fuels, and increasing carbon sinks, such as by expanding forests, since trees capture carbon from the atmosphere as they grow. Cambodia's vision for carbon neutrality is founded on the country's strong political commitment in the FOLU sector. Under the LTS4CN scenario, full implementation of the REDD+ Investment Plan will drive afforestation and reforestation activities. The FOLU sector is expected to become a significant carbon sink in 2050, leaving room for other sectors to incrementally transition towards carbon neutrality.

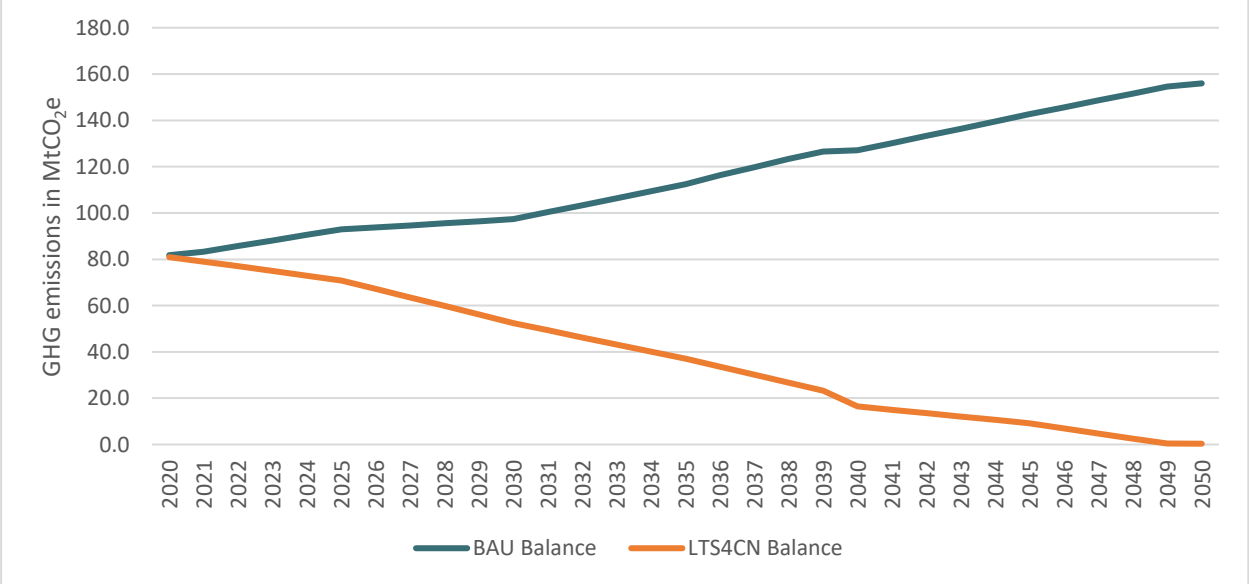


*Figure 6: GHG emissions projections in the BAU and LTS4CN scenarios*

The LTS4CN scenario suggests that Cambodia could achieve overall carbon neutrality in 2050 with the FOLU sector providing a total carbon sink of about 50 $MtCO_2e$. The waste and IPPU sectors will be the least emitting sectors in 2050 with 1.6 and 1.2 $MtCO_2e$, respectively. The energy sector is expected to be the highest emitter at 28 $MtCO_2e$, followed by agriculture at 19 $MtCO_2e$ (Figure 6).

*Table 2: GHG emissions projection by sector in 2050, BAU and LTS4CN scenarios*

| Sector | BAU scenario, $MtCO_2e$ | Emissions reduction in LTS4CN scenario, $MtCO_2e$ | Emissions balance in LTS4CN scenario, $MtCO_2e$ |
|---|---|---|---|
| **Agriculture** | 34.9 | -15.6 | 19.3 |
| **Energy** | 82.7 | -54.3 | 28.2 |
| **FOLU** | 21.2 | -71.4 | (-50.2) |
| **IPPU** | 10.7 | -9.1 | 1.6 |
| **Waste** | 6.5 | -5.3 | 1.2 |
| **Total** | 156.0 | 155.6 | 0,3 |

Compared to the BAU scenario, where carbon emissions are expected to increase to up to 156 $MtCO_2e$ in 2050, the LTS4CN scenario would cumulatively avoid about 1,400 $MtCO_2e$ of emissions over 30 years (Figure 6). Reaching carbon neutrality is possible if the FOLU sector can develop a significant carbon sink and all other sectors gradually reduce their emissions to the levels suggested in Table 2.

Total emissions in the LTS4CN scenario are projected to decline gradually until 2040, with the decrease slowing between 2040 and 2050, as summarized in Figure 7. Figure 13 summarizes major mitigation actions and targets for each sector.

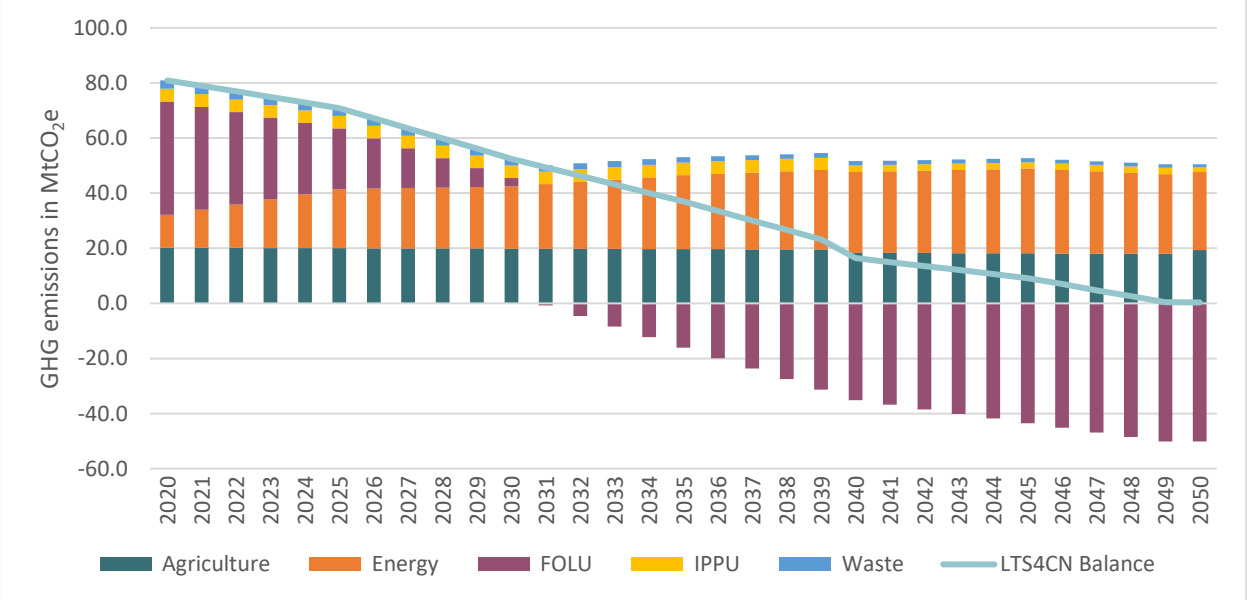


*Figure 7: GHG emissions projections in the LTS4CN scenario with sectoral shares*

The LTS4CN scenario introduces eight mitigation actions for the agriculture sector to avoid a total of 16 $MtCO_2e$ in 2050. That corresponds to an emissions reduction of 45 percent compared to the BAU scenario. Major decreases of emissions in crop cultivation can be achieved by using less methane-intensive rice cultivars, direct seeding practices, alternate wetting and drying practices, and organic fertilizer and, deep fertilizer technology. In livestock management, mitigation measures are feed additives for cattle, improved fodder management and the wide application of composting technology.

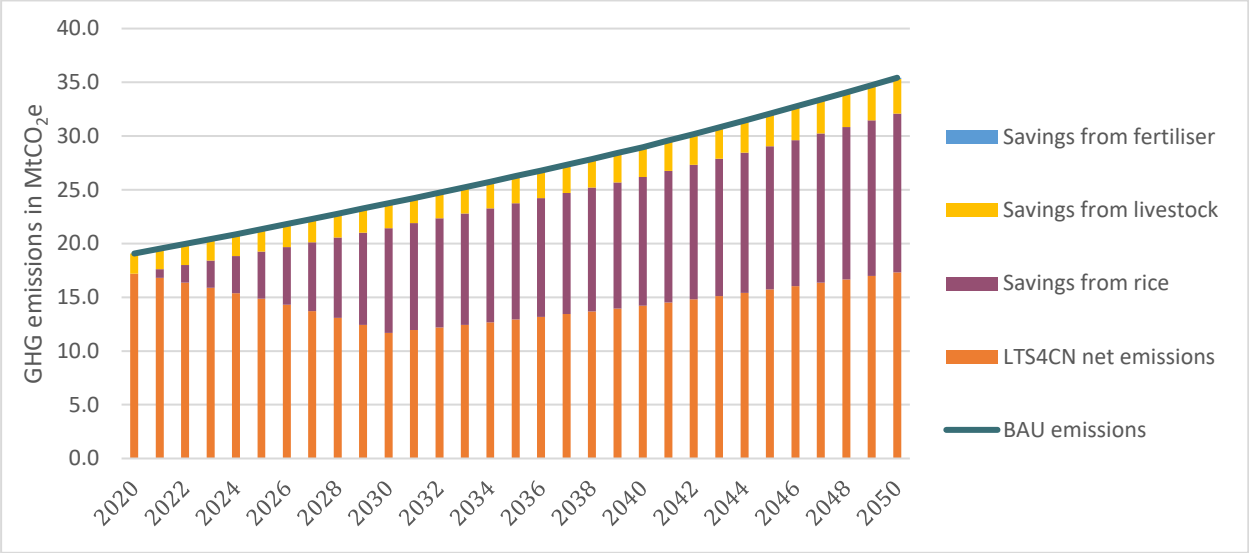


*Figure 8: GHG emissions projections for the agriculture sector in the LTS4CN scenario*

The FOLU sector consultation and modelling process suggested a "green highway" scenario where forests provide a carbon sink of 50 $MtCO_2e$ in 2050 and are the main driver of carbon neutrality (Figure 9). This can be achieved through implementing ambitious sector policies and strategies starting from the early 2020s, including the full implementation of the existing REDD+ Investment Plan until 2050. Five key sectoral mitigation actions under the LTS4CN scenario are reducing deforestation, afforestation and reforestation, improved forest management, assisted natural regeneration[9] of native forests and riparian landscapes, and agroforestry.

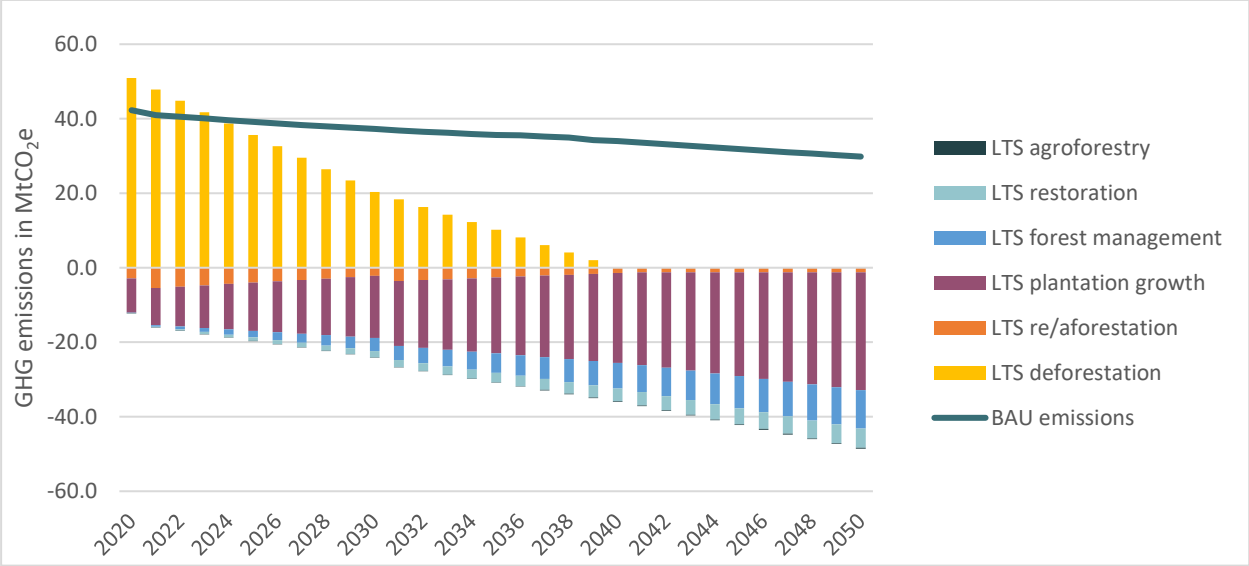


*Figure 9: GHG emissions projections for the FOLU sector in the LTS4CN scenario*

Cambodia's LTS4CN scenario for the energy sector can lead to significant emissions reductions by progressively prioritizing three main actions: energy efficiency and conservation, shifts to low-carbon sources and decarbonization of electricity production. The scenario projects the energy sector would emit only 28 $MtCO_2e$ by 2050 (Figure 10), an emissions reduction of 66 percent compared to the BAU scenario.

Major emissions saving comes from energy efficiency in buildings and industry, the switch to electricity for domestic cooking, and coal substitution and abatement in the industrial, and power sectors. Incremental decarbonization of the power sector is suggested through a moderate share of

[9] Assisted natural regeneration is the human protection and preservation of natural tree seedlings in forested areas.

renewable energy in the generation mix until 2050, while using natural gas as a transitional fuel. That requires substantial investment in combined-cycle gas turbine (CCGT) power plants and LNG import capacity. In the transportation sector, emissions savings can be achieved by developing rail for passengers and freight, urban public transportation, and the electrification of the passenger and, light-duty vehicle fleet.

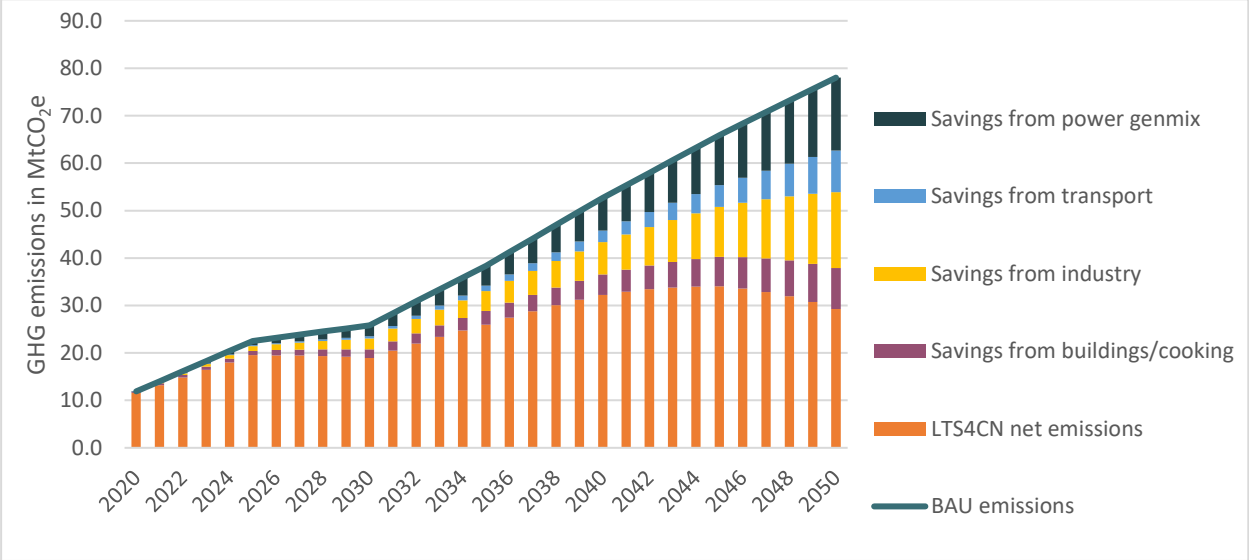


*Figure 10: GHG emissions projections for the energy sector in the LTS4CN scenario*

The LTS4CN scenario suggests five mitigation actions for the IPPU sector that could avoid a total of 9.1 $MtCO_2e$ of emissions compared to 10.7 $MtCO_2e$ under BAU. These priority actions aim to reduce emissions in cement production and use as well as the climate impact of refrigerants. They include promoting clinker substitution and carbon capture and storage in cement production as well as the recycling of aggregate concrete. The refrigeration and air-conditioning market would need to implement use of refrigerants with low global warming potential, accompanied by regular inspection of equipment and recovery of spent refrigerants (Figure 11).

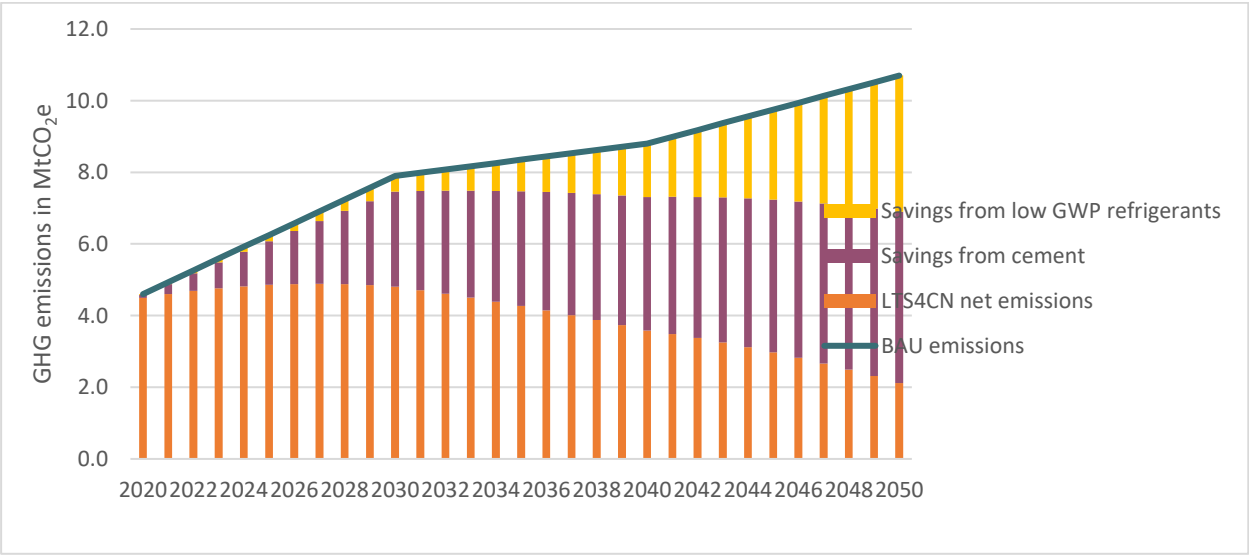


*Figure 11: GHG emissions projections for the IPPU sector in the LTS4CN scenario*

The waste sector would reduce its emissions to 1.2 $MtCO_2e$ in 2050 in the LTS4CN scenario (Figure 12). This can be achieved by improving waste collection rates; implementing reduce, reuse, and recycle principles; producing biogas and compost from organic waste; eliminating open burning; extracting landfill gas and producing refuse derived fuel; and improving treatment of wastewater.

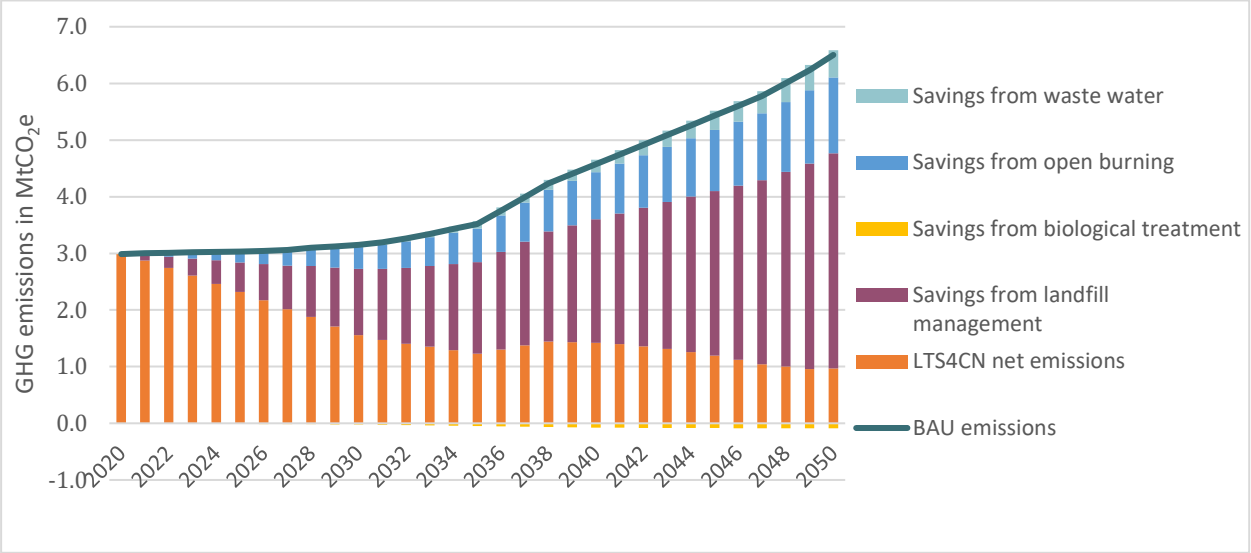


*Figure 12: GHG emissions projections for the waste sector in the LTS4CN scenario*

| | | |
|---|---|---|
|  | **Agriculture** | • Less methane-intensive rice cultivars<br>• Direct seeding practices<br>• Alternate wetting and drying practices<br>• Promotion of organic fertilizer and deep fertilizer technology<br>• Feed additives for cattle<br>• Improved fodder management<br>• Introduction of composting technology |
|  | **Forestry and other land uses** | • Reducing the deforestation rate by 50 percent in 2030<br>• Stopping deforestation by 2045<br>• Afforestation, improved forest management and forest restoration<br>• Agroforestry and commercial tree plantation<br>• Full implementation of the REDD+ Investment Plan by 2050 |
|  | **Energy** | • No new coal generation capacity beyond already committed projects<br>• Use of natural gas as a dispatchable transition fuel<br>• Investments in LNG import, storage and infrastructure<br>• Increase in solar, hydro, biomass and other renewables to 35 percent of the generation mix by 2050, of which 12 percent is from solar<br>• Investments in grid modernization, flexibility and storage<br>• Energy efficiency measures in buildings and industry<br>• Fuel switching to electricity for cooking<br>• Substitution of coal in the industrial and power sector |
|  | **Transportation** | • More use of public transportation – 30 percent modal share in urban areas by 2050<br>• Moderate penetration of electric vehicles – 70 percent for motorcycles and 40 percent for cars and urban buses by 2050<br>• Increased fuel efficiency for internal combustion engine vehicles<br>• Rail for freight and passengers<br>• CNG penetration of 80 percent for interregional buses and 80 percent for trucks until 2050 |
|  | **Industrial processes and product use** | • Clinker substitution in cement production<br>• Carbon capture and storage for cement kilns<br>• Use of recycled aggregate concrete<br>• Increasing use of refrigerants with low global warming potential<br>• Regular inspection of refrigeration and air-conditioning equipment and recovery of spent refrigerants |
|  | **Waste** | • Reducing open burning by expanding waste collection coverage to 85 percent in 2050<br>• Implementing a reduce, reuse, and recycle strategy<br>• Landfill gas management<br>• Organic composting<br>• Anaerobic digestion and wastewater treatment |

*Figure 13: Summary of key mitigation actions by sector*

## 2.2. Economic costs and benefits

The sector analysis entailed consultations to identify 31 key actions contributing to carbon neutrality. Discussions of a long list of options led to the selection of five to eight key actions per sector that capture the main opportunities for achieving carbon neutrality. Some actions bundle sets of more detailed actions. An assessment of economic costs and benefits of the 31 key actions built on an Extended Cost Benefit Analysis (see more details in separate the Technical Annex).

The LTS4CN scenario creates estimated net economic benefits for the public and private sectors of about $5 billion in 2050 (3 percent of projected GDP). Further benefits will include $1 billion in adaptation co-benefits from LTS4CN actions. Wider social and environmental benefits would reach $6 billion, mainly from FOLU actions. Full net benefits start from the first year of the LTS4CN and grow to more than $11 billion in 2050, which is 7.5 percent of projected GDP that year (see Section 3 for more details). This would compensate for about two thirds of the GDP lost due to climate change impacts, as estimated in the Climate Economic Growth Impact Model (CEGIM) for Cambodia.

*Table 3: Total costs and benefits by public and private capital and operating expenditures*

| | **Annual costs (orange) and benefits (green), millions of dollars** | | |
|---|---|---|---|
| | **2030** | **2040** | **2050** |
| **Private capital expenditures** | 473 | 743 | 1,384 |
| **Private net annual costs** | 812 | 2,376 | 6,254 |
| **Public capital expenditures** | 159 | 294 | 476 |
| **Public net annual costs** | 59 | 69 | 176 |
| **Adaptation benefits** | 346 | 630 | 994 |
| **Wider benefits (social and environmental)** | 1,393 | 3,466 | 5,977 |
| **Total costs and benefits** | **1,859** | **5,366** | **11,188** |

By 2050, the private sector would be investing nearly $1.4 billion each year, mainly in energy, transportation and forestry, with some significant investment in the IPPU. Private-sector operating expenditure benefits are six times initial investment costs and come from a wide range of actions. Benefits are high from energy efficiency ($3.4 billion), vehicle electrification ($1.1 billion) and rail and freight haulage ($1.1 billion). These are reduced by nearly $800 million, however, due to the opportunity costs of protecting forest from conversion to agriculture. Public capital expenditure is relatively small, with some ongoing investment in renewable energy, buses, trains, and forestry, in line with the REDD+ Investment Plan. There are significant ongoing public operating expenditures, dominated by rail and haulage ($500 million) and the loss of a fuel tax from the electrification of vehicles ($200 million). These costs are offset by operating profits from renewable energy, however. The net contribution of the agriculture, waste, and IPPU sectors is small.

*Table 4: Economic and wider benefits per year*

| | Benefits as a percentage of GDP | | |
|---|---|---|---|
| | **2030** | **2040** | **2050** |
| **Economic benefit** | 0.2 | 1.3 | 2.8 |
| **Adaptation co-benefits** | 0.6 | 0.6 | 0.7 |
| **Wider social and environmental benefits** | 2.6 | 3.6 | 4.0 |
| **Total** | **3.4** | **5.5** | **7.6** |

### 2.2.1. Public sector costs

Public costs are dominated by operating expenditures in the energy and transportation sectors, including costs associated with rail and freight and loss of a fuel duty from electrification. While public transportation fares will gradually increase to reduce the subsidy required for bus operations, this will be more than offset by the steady rise in the loss of a fuel duty due to the electrification of cars. These costs could be reduced or even entirely avoided by introducing other forms of vehicle taxation and building demand for buses and trains so that pricing policies can make bus and rail operators profitable.

There are smaller net costs in the forestry sector, mainly from lost forestry royalties, but also from the costs of supporting reforestation, afforestation, improved forestry management and restoration of degraded forest. Costs of public support average $17 million per year in the first 10 years of the LTS4CN scenario, consistent with the REDD+ Investment Plan, which requires $16 million per year.

### 2.2.2. Public financing plan

The LTS4CN will require substantial public investment over 30 years (Table 5). A proposed public financing plan suggests devoting 1 percent of new public borrowing to the LTS4CN and making a small shift in public spending on economic services to divert 2 percent to LTS4CN actions. These two measures provide 40-50 percent of financing needs. The financing plan assumes the gradual introduction of pricing policies and taxation reform in the transportation sector, which will cover 90 percent of transportation sector costs by 2050.

The remainder of public finance needs will be met by international climate finance. This will include major investment in public transportation and rail freight as well as support for the forestry sector and financing for carbon capture and storage and, grid flexibility.

*Table 5: Public financing needs and financing plan*

| | Public financing needs, millions of dollars | | | | | | |
|---|---|---|---|---|---|---|---|
| | **2025** | **2030** | **2035** | **2040** | **2045** | **2050** | **Total 2025-2050** |
| **New public borrowing (1 percent)** | 19 | 28 | 38 | 52 | 65 | 83 | 1,212 |
| **Economic services spent (3 percent)** | 44 | 63 | 85 | 115 | 146 | 186 | 2,724 |
| **Policy reform in the transportation sector** | 10 | 33 | 75 | 103 | 111 | 334 | 2,727 |
| **International climate finance** | 62 | 94 | 118 | 93 | 61 | 50 | 2,333 |
| **Total** | **135** | **218** | **316** | **364** | **383** | **652** | **8,997** |

## 2.3. Technology and capacity needs

Technology and capacity needs are crucial for successful LTS4CN implementation, especially for the Department of Climate Change, the Climate Change Technical Working Group, and sectoral and subnational technical working groups. They are the enablers of adaptation and mitigation actions and commitments. Without proper capacity and technology, it will be difficult although not impossible for Cambodia to achieve carbon neutrality by 2050. The following subsections summarize key technology and capacity needs for each sector.

### 2.3.1. Agriculture sector

Major barriers to LTS4CN actions in agriculture include conflicting land use demands, the clash between regional and sectoral implementation plans, and the significant energy required for manufacturing organic fertilizers. Transformations are required to improve agriculture productivity, increase land use efficiency and enhance planning and implementation, among others. Table 6 details the challenges and required technology and capacity.

*Table 6: Technology and capacity needs in the agriculture sector*

| Major challenges and barriers | Transformation needed | Required transformative policy measures and capacity | Responsible actors |
|---|---|---|---|
| Demand for land in agriculture (rice crop cultivation) with population growth; emissions reduction target in the FOLU sector. | Improvement in agriculture productivity.<br><br>Increasing land use efficiency (including integrated farming or complex agroforestry).<br><br>Enhanced commitment of large-scale businesses to environmentally sound practices. | Research on high productivity agricultural technologies;<br>capacity building for farmers to enable them to use high-quality seeds and adopt improved technologies and practices.<br><br>Optimization of the use of unproductive land in non-forest areas for cropland expansion, along with the enforcement of bans on the conversion<br>of agricultural lands to other land uses.<br><br>Provision of incentives for contributions to emissions reductions and other environmental benefits. | Ministry of Agriculture, Forestry and Fisheries |
| The clash between regional and sectoral pathway implementation plans. | Enhanced effectiveness of the planning and implementation of the two pathways. | Policy and programme alignment among line ministries, among regions, and between ministries and local governments (vertical and horizontal alignment) and coherent institutional arrangements. | Ministry of Agriculture, Forestry and Fisheries; Ministry of Public works and transport; Ministry of Health; Ministry of Mines and Energy; and Ministry of Planning |

| | | | |
|---|---|---|---|
| Energy required for manufacturing organic fertilizers (crushing, drying and transportation) to replace inorganic fertilizer. If organic fertilizer is produced in Cambodia, it will have an impact on the energy sector. | Technical and economic feasibility assessments to produce organic fertilizer.<br><br>Promotion of solar-powered organic fertilizer manufacturing.<br><br>Promotion of regional organic fertilizer manufacturing to reduce transportation emissions. | Provision of incentives or tax benefits for starting regional organic fertilizer plants.<br><br>Special provisions and tax benefits for organic fertilizer used by food manufacturers. | Ministry of Agriculture, Forestry and Fisheries |

### 2.3.2. Energy sector

The main barriers to the LTS4CN scenario in the energy sector include obstacles to electric cooking, large-scale displacement of coal in industries, challenges to increase clean transportation, develop collective transportation and a sustainable transportation economy, increase variable renewable energy, the use of natural gas in the power and transportation sectors, and develop "behind the meter" distributed energy resources. Table 7 suggests how to address these barriers to achieve necessary transformations.

*Table 7: Technology and capacity needs in the energy sector*

| Major challenges and barriers | Transformation needed | Required transformative policy measures and capacity | Responsible actors |
|---|---|---|---|
| Barriers to electric cooking are significant in terms of device accessibility, cooking habits, and widespread access to reliable and, affordable clean electricity. | Active promotion of quality, efficient electric cooking equipment (beyond rice cookers) to households, graduating to clean cooking where the electric grid is reliable.<br><br>Expansion of the electric grid to allow the transition to electric clean cooking. | Significant investments in the power sector and incentives for low- and middle-income households to adopt quality electric cooking devices will be necessary to support the switch to electric cooking. | Ministry of Mines and Energy<br><br>Electricite du Cambodge (electric utility)<br><br>Ministry of Industry, Science, Technology and Innovation |
| The large-scale displacement of coal in industries depends on the reliable availability of sustainable biomass and waste that are homogeneous and have high energy content. | Supply chains for collection of biomass residues (mainly from processing to limit negative impacts on soil fertility) and waste need to be structured. Investments in drying, torrefaction, and densification technologies are necessary to realize fuel quality. | Allocation of a budget for research on biomass densification technologies and torrefaction.<br><br>Provision of incentives or subsidized loans for industries investing in biomass residue processing for the domestic market. | Ministry of Industry, Science, Technology and Innovation |
| Increasing clean transportation (electric vehicles, CNG, etc.) across all transportation segments requires fueling | Development of regulatory frameworks and a policy environment to encourage electric vehicles and | | Ministry of Mines and Energy<br><br>Ministry of Public Works and Transport |

| Major challenges and barriers | Transformation needed | Required transformative policy measures and capacity | Responsible actors |
|---|---|---|---|
| and maintenance infrastructure. | alternative fuels uptake.<br><br>Implementation of a charging station network for electric vehicles.<br><br>Implementation of a CNG/LNG fueling network for trucks that cannot move to electric vehicles.<br><br>Grid reinforcements and modernization to accommodate electric vehicle loads.<br><br>Development of competencies and market offerings for vehicle maintenance and distribution.<br><br>Study of hydrogen or other zero-carbon fuels as long-term alternatives to natural gas for the trucking sector. | | Ministry of Industry, Science, Technology and Innovation<br><br>Electricite du Cambodge<br><br>Private sector |
| Development of collective transportation and a sustainable transportation economy. | Planning and financing for public transportation and passenger and freight rail expansions.<br><br>New transportation paradigms, encompassing new technologies, innovative modes of travel organization and behaviour changes.<br><br>Reinforcement of transportation management competencies in urban municipalities and/or selection of operators.<br><br>Development of competencies and market offerings for other collective transportation services such as carpooling | Government setting a long-term vision for transportation and planning accordingly.<br><br>Capacity building for local authorities and transportation companies (operators, manufacturers, etc.).<br><br>Development of courses at all levels for initial training on green transportation and continuous learning.<br><br>Support to start-ups or local businesses in the sector.<br><br>Incentives and promotion campaigns, including potential subsidies for collective transportation (rail, public transportation).<br><br>Set up policies to facilitate the deployment of new transportation modes (example, low emission zone LEZ, car parks, etc.). | Ministry of Public Works and Transport<br><br>Ministry of Industry, Science, Technology and Innovation |

| Major challenges and barriers | Transformation needed | Required transformative policy measures and capacity | Responsible actors |
|---|---|---|---|
| Increasing variable renewable energy (wind, solar photovoltaic) in the power sector implies major investments in generation capacity, grid modernization and flexibility, and storage. | Resource mapping and identification of renewable energy sources.<br><br>Incentives, policy targets and tariff structures to encourage renewable energy investments.<br><br>Human resources/capacity to support integrated renewable energy planning, installation and operations.<br><br>Modernized power system operation (generation fleet, dispatch and grid code) and development of storage to adapt to resource intermittence.<br><br>Contracts and tariffication methodologies that better account for flexibility in needs and risks related to variability.<br><br>Competitive renewables and storage procurement.<br><br>Consumer behaviour change to shift demand to times with high resource availability. | Development of policy targets for variable renewable energy penetration.<br><br>Development of a prospectus of priority sites for project development.<br><br>Institutionalization of auction mechanisms for procurement of renewable energy projects on priority sites.<br><br>Development and introduction of flexible terms for dispatchable generation capacity to allow ancillary services.<br><br>Development and introduction of time-of-use tariff policies.<br><br>Capacity building for government/energy sector officials on integrated power planning, resource mapping and regulation/tariffication.<br><br>Labour development policies to train personnel for renewable energy systems operations, clean energy technicians, etc. | Ministry of Mines and Energy<br><br>Electricite du Cambodge<br><br>Electricity Authority of Cambodia<br><br>Ministry of Industry, Science, Technology and Innovation |
| Use of natural gas in the power sector (CCGT) and transportation (CNG for heavy-duty vehicles) will require import, storage and potentially transportation infrastructure for LNG. | Planning and financing of natural gas infrastructure investments.<br><br>Consideration of the long-term flexibility and resilience of natural gas infrastructure with respect to a potential shift to zero-carbon gases such as hydrogen, and potential threats from market disruptions or climate events. | Government vision-setting and master plans on the long-term role of natural gas in the energy sector.<br><br>Training/capacity building for public officials on natural gas procurement, operations, regulations, environmental risks, etc.<br><br>Labour force training for operators at port, storage or transportation facilities.<br><br>Allocation of a budget for research on the long-term potential for natural gas alternatives such as hydrogen. | Ministry of Mines and Energy<br><br>Ministry of Public Works and Transport<br><br>Ministry of Industry, Science, Technology and Innovation |

| Major challenges and barriers | Transformation needed | Required transformative policy measures and capacity | Responsible actors |
|---|---|---|---|
| | Capacity development for operations and maintenance of related infrastructure and equipment.<br><br>Development of a regulatory environment to support import, distribution, pricing and health, safety and environment (HSE) oversight. | | |
| Development of "behind the meter" distributed energy resources will contribute to reducing overall emissions from the building sector and decrease pressure on grid-connected generation capacity, but large-scale integration creates technical and regulatory challenges. | Development of a policy and regulatory environment for distributed energy integration in the built environment.<br><br>Development of a market offering (specialized equipment suppliers, real estate developers, etc.) for distributed energy in residential and commercial buildings.<br><br>Grid and regulatory adaptations if excess energy is reinjected into the grid. | Incentives for individuals or developers to integrate distributed energy into building constructions<br><br>Support to businesses in developing distributed energy offerings.<br><br>Integration of distributed energy in building codes and electricity distribution regulations.<br><br>Policy intervention in urban planning and design (reduce carbon footprints and contribute to spatial development sustainability, etc.) | Ministry of Land Management, Urban Planning and Construction<br><br>Ministry of Mines and Energy<br><br>Electricity Authority of Cambodia |

### 2.3.3. FOLU sector

For the FOLU sector, gaps in the technical capacity for measurement, reporting and verification (MRV) were identified as emphasized in the 2020 Biennial Update Report and the Updated NDC. Capacity gaps relate to a lack of in-depth understanding of the technical aspects of GHGs and mitigation actions, including the detailed set of modalities, procedures and guidelines under the Enhanced Transparency Framework, GHG inventories, mitigation analysis, climate vulnerability and adaptation assessments, projection methods for emissions and removals, quality assurance and control, and technical support for improving activity data and emissions factors. Also important is improving institutional capacity for monitoring and evaluation to enhance reporting on mitigation, adaptation, and support needed and, received. Table 8 provides an overview.

*Table 8: Technology and capacity needs in the FOLU sector*

| Major challenges and barriers | Transformation needed | Required transformative policy measures and capacity | Responsible actors |
|---|---|---|---|
| Speed of project and/or investment implementation. | The FOLU sector benefits from programmes already in place. The REDD+ Investment Plan is a key initiative that will require full funding and implementation. | Leadership and political commitments. | Ministry of Environment |
| Access to climate finance. | Targets will require an optimal use of funding and new climate finance. | Capacity building for developing grants and investment proposals. | Ministry of Environment; Ministry of Agriculture, Forestry and Fisheries; Ministry of Planning; and partners |
| Access to innovations in satellite imagery and monitoring. | A major aspect of mitigation relies on clear zoning and monitoring of forests. | Capacity building, access to funding and a budget allocation for research on effective monitoring systems. | Ministry of Environment |
| Implementation of the first National Forest Inventory. | Statistical sampling approaches for land use changes and accurate emissions factors must account for all of the carbon pool. | Leadership, capacity building, experimental research and access to funding. | Ministry of Environment; Ministry of Agriculture, Forestry and Fisheries |
| Data collection system for harvested wood products. | Systematic data collection on harvested wood products for local consumption and export, including biomass use for energy. | Leadership, capacity building and access to funding. | Ministry of Agriculture, Forestry and Fisheries; Ministry of Environment; Ministry of Planning |
| Other emissions from forest conversion and forest fires. | Accounting for all major GHGs: carbon dioxide, methane and nitrous oxide. | Leadership, capacity building and experimental research. | Ministry of Agriculture, Forestry and Fisheries; Ministry of Environment |
| Growth and yield for natural forests and plantations of non-native and native species. | Sinks are clearly estimated under specific forest types and plantations. | Leadership, capacity building and experimental research. | Ministry of Agriculture, Forestry and Fisheries; Ministry of Environment |
| Exposure to natural disasters and fires. | With higher forest cover and a focus on afforestation, mitigation strategies will need to reduce impacts on forests from natural disasters and the risk of fires. | Access to funding and innovations to increase the resilience of the forestry sector. | Ministry of Environment; Ministry of Agriculture, Forestry and Fisheries |

### 2.3.4. IPPU sector

Several major barriers in the IPPU sector include the long-distance transportation of captured carbon, the use of several products for clinker substitution, the risk of increased emissions from recycling aggregate concrete, and the impact of refrigeration and air-conditioning systems on global warming. Needed transformations could build on technical and economic feasibility assessments to determine carbon capture readiness, the allocation of bare lands away from residential areas for carbon storage, the introduction of novel technologies and national-level research on using refrigerants with low global warming potential. Table 9 summarizes major challenges and outlines required technology and capacity.

*Table 9: Technology and capacity needs in the IPPU sector*

| Major challenges and barriers | Transformation needed | Required transformative policy measures and capacity | Responsible actors |
|---|---|---|---|
| Secure storage of captured carbon requires extensive isolated land areas apart from industrial and urban zones. Captured carbon therefore needs to be transported long distances, which may add significant transportation emissions (energy sector). | Technical and economic feasibility assessments to determine carbon capture readiness in the country.<br><br>Allocation of bare lands that are away from residential areas and are not suited for agriculture or forestry.<br><br>Industry collaboration on a megascale project to optimize transportation, rather than relying on individual industries. | Allocation of a budget for research on innovative cost-effective carbon capture and storage technologies.<br><br>Policy changes for Special Economic Zones to implement carbon capture and storage.<br><br>Provision of incentives or subsidized loans for industries willing to implement carbon capture and storage. | Ministry of Industry, Science, Technology and Innovation; Ministry of Environment |
| Using several products for clinker substitution, such as reduced coal ash powder waste and fly ash etc., requires extra land to dispose of waste. This can cause land and water pollution. | Allocation of bare lands for waste disposal that are away from residential areas and waterways, and that are not suitable for agriculture or forestry. | Industrial policy change (mandate for the cement industry) to move towards cement with less clinker composition as a sustainable product.<br><br>Provision of incentives or subsidized loans for cement industries willing to implement clinker substitution. | Ministry of Industry, Science, Technology and Innovation; Ministry of Environment |
| Recycling aggregate concrete requires a special process including crushing technology, which may be energy-intensive and increase energy sector emissions. | Introduce novel technologies. | Policy changes for Special Economic Zones to allow recycled aggregate concrete.<br><br>Provision of incentives or subsidized loans for industries willing to recycle aggregate concrete. | Ministry of Industry, Science, Technology and Innovation; Ministry of Environment; and Ministry of Mines and Energy |
| The impact of refrigeration and air-conditioning systems on global warming is through both energy use and refrigerant emissions. | National-level research on using low global warming potential refrigerants.<br><br>Refrigerants | Impose restrictions or bans on high global warming potential refrigerants. | Ministry of Environment |

| Major challenges and barriers | Transformation needed | Required transformative policy measures and capacity | Responsible actors |
|---|---|---|---|
| Nearly 80 percent of total emissions comes from energy, while 20 percent relates to refrigerants. Refrigerant fluids are chosen for their thermodynamic efficiency to extract heat and for their safety in use. Replacing high global warming potential refrigerants with low potential ones inevitably involves a loss of refrigerating efficiency, which increases energy use. As a result, electricity consumption and emissions may increase. | assessment for life cycle emissions of refrigeration/air-conditioning equipment. | New industrial law to increase the frequency of equipment checks; implementation of the law on managing the release of gases.<br><br>Introduction of a national-level methodology for end-of-life disposal. | |

### 2.3.5. Waste sector

Several main barriers to the LTS4CN in the waste sector include gaps in solid data; the lack of clear government investment policies, incentives and mechanisms; insufficient institutional capacity; and limited public participation and awareness. Necessary transformations, among others, centre on installing weighbridges and matters, developing a central database and conducting waste composition studies. Table 10 provides an overview.

*Table 10: Technology and capacity needs in the waste sector*

| Major challenges and barriers | Transformation needed | Required transformative policy measures and capacity | Responsible actors |
|---|---|---|---|
| The sector faces a general lack of solid data. Data are usually produced using estimations per capita instead of actual measurements, such as tonnage of waste sent to landfills. There is no centralized database that can be easily accessed. | Install weighbridges at new landfills and meters at new wastewater treatment plants with a proper data collection system.<br><br>Develop and organize a central database that is kept up to date.<br><br>Conduct studies on the composition of municipal solid and industrial waste and leakages to the environment, and analyse focal sludge. | Allocation of a budget for infrastructure and information technology.<br><br>Establish clear roles and responsibilities for data collection, reporting and analysis. | Ministry of Public Works and Transport; Ministry of Environment; Ministry of Industry, Science, Technology and Innovation; subnational administrators |
| The lack of clear government investment policies, incentives and mechanisms is hindering private sector investment and participation. | All proposed technologies are proven at commercial scale. Some are expensive and complex to run, however, requiring the participation of specialized international companies. Clear articulation and implementation of | Develop enabling investment policies, standardized power purchase agreements, an appropriate fee-in tariff for electricity and gate fees at waste processing centres. | Ministry of Economy and Finance, Ministry of Environment, Ministry of Public Works and Transport |

| Major challenges and barriers | Transformation needed | Required transformative policy measures and capacity | Responsible actors |
|---|---|---|---|
| | government investment policies and incentives will enable international private sector participation. | Organize competitive public procurement to attract global developers and investors.<br><br>Offer land allocations and concessions for waste management facilities. | |
| A lack of institutional capacity to assess and regulate new technologies, including environmental and social safeguards. Environmental impact assessments are outsourced only to local firms that may not have capabilities to assess new technologies. | Reinforce and clarify the regulatory framework and focus on capacity building within government institutions, including for subnational administrators with direct oversight responsibilities for waste infrastructure and operations. | Strengthen and implement the regulatory/legislative framework (environmental impact assessments, licensing process).<br><br>Improve monitoring and regulatory oversight.<br><br>Institutional capacity building. | Ministry of Environment; Ministry of Public Works and Transport; subnational administrators |
| Limited public participation and awareness hinder waste management improvement. | Public participation and buy-in during the development of policy and infrastructure. Ongoing awareness raising on environment issues and regulations applying to the community. | Long-term awareness campaigns and guidance.<br><br>Provision of infrastructure to facilitate compliance (e.g., bins, signage).<br><br>Implementation of regulations (e.g., issuing fines for repeated non-compliance). | Ministry of Environment; Ministry of Public Works and Transport; subnational administrators |

# 3. Socioeconomic Benefits

## 3.1. Costs and benefits of LTS4CN actions

Figure  presents the evolution of net costs and benefits for each of the 31 actions in the LTS4CN. Ten actions account for over 90 percent of total costs and benefits, covering both public and private costs. Actions with the highest net benefits are at the bottom of the figure; actions with the highest net costs are at the top.

Major costs are from lost timber and farming revenues arising from reduced deforestation, along with expenditures on carbon capture and storage and to some extent for public transportation over the first decade. Forest restoration also requires net costs in the same period.

Four actions would deliver substantial net benefits. Public transportation benefits arise from reduced vehicle operation costs, and time savings among commuters on all modes of transportation due to lower congestion. Renewable energy is profitable through most of the time. Road and rail haulage and switching to low global warming potential refrigerants are also profitable.

The private sector would see very strong benefits from energy efficiency. Afforestation yields steadily growing benefits. The electrification of vehicles in the last decade of the period delivers nearly $500 million of benefits by 2050.

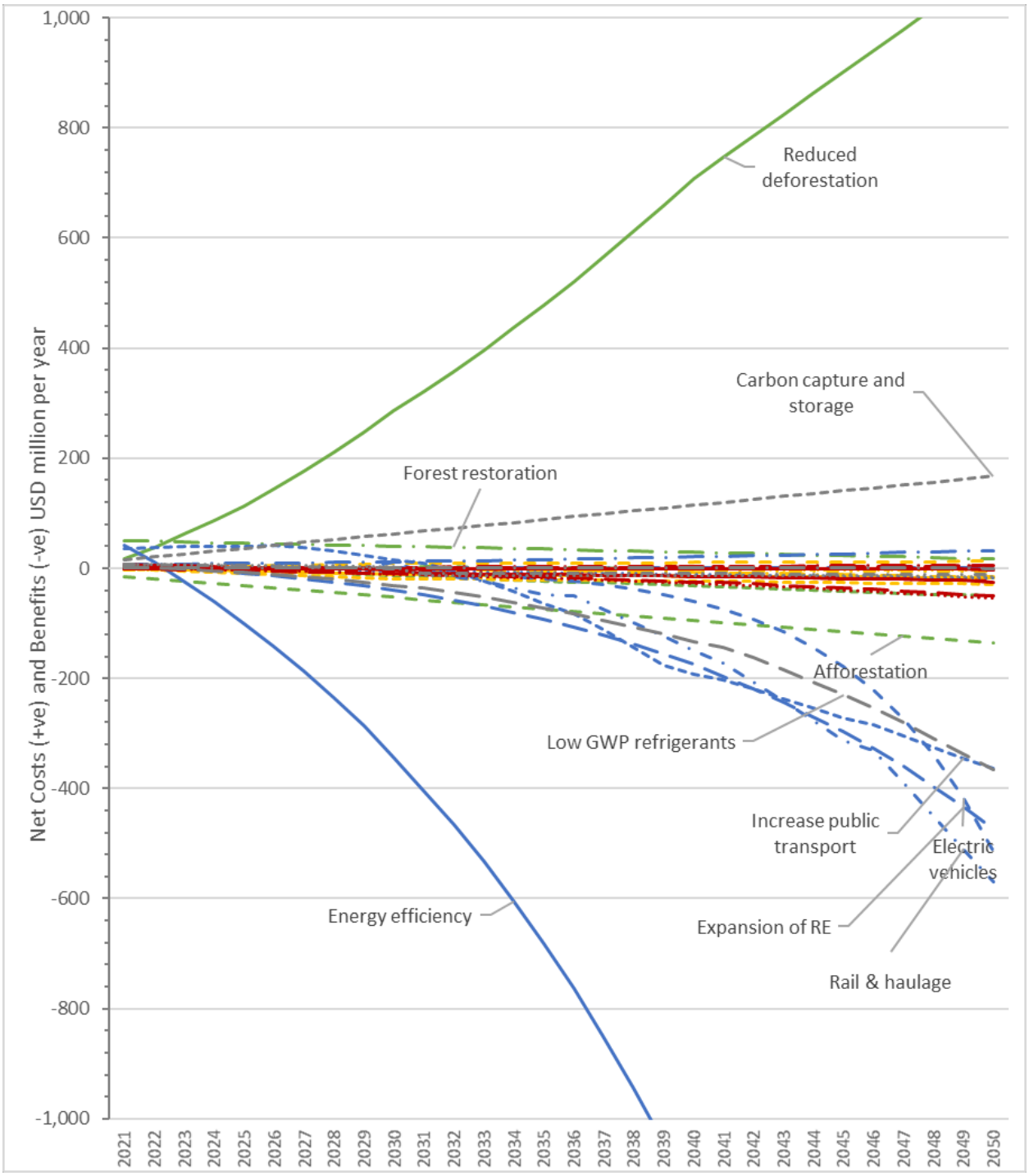


*Figure 14: Costs and benefits of key LTS4CN actions, including public and private capital and operating expenditures*

A marginal abatement cost (MAC) curve describes both the cost effectiveness of the action (on the y-axis) and the scale of its potential contribution to emission reductions (on the x-axis). This Figure presents a MAC curve for the LTS4CN, with the average cost effectiveness over the period on the y-axis and the potential reduction in GHG emissions by 2050 on the x-axis. Labels for smaller actions are removed to make the MAC curve more legible. The more cost-effective actions appear to the left of the curve.

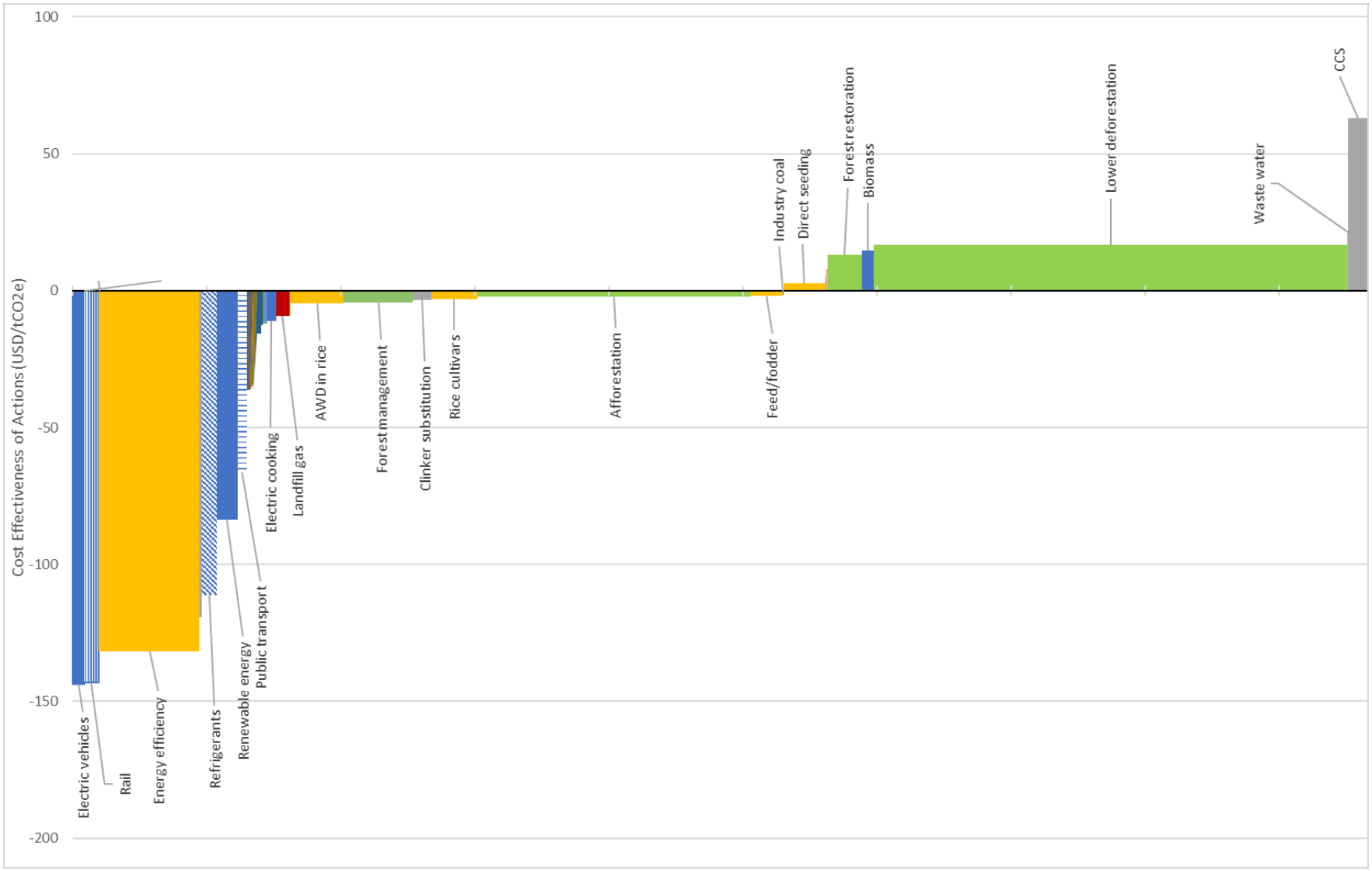


*Figure 15: The MAC curve for 2050*

The MAC curve provides a guide to help prioritize actions. It offers only a broad overview, however, and simplifies key issues, including changes in cost effectiveness due to technical innovation and market conditions, and greater expense as actions are scaled up. Despite these shortcomings, some conclusions are possible.

- About 15 percent of emissions reductions comes from six actions that are strongly profitable: energy efficiency, rail, refrigerants, renewable energy, electric vehicles, and public transportation;
- About 50 percent of reductions can be achieved by actions that are marginally profitable, including, in particular, afforestation, forest management, and rice practices; and
- The remaining 35 percent of reductions require actions with net costs. These reductions are dominated by reduced deforestation and carbon storage and capture.

## 3.2. Total economic costs and benefits

The economic analysis suggests that the LTS4CN create net economic benefits for the public and private sector even before accounting for adaptation and wider social and environmental benefits. These net benefits start from the first year of the LTS4CN and grow to more than $4 billion in 2050, over 2.8 percent of projected GDP that year.

**Public and private sectors:** Figure  shows that public sector costs start at relatively modest levels and grow steadily through the period, reaching nearly $1 billion or 0.7 percent of GDP in 2050. The private sector experiences strong net benefits from the second year, reaching $1 billion in 2036 and growing strongly for the remainder of the period. The figure also shows, however, that these net benefits require significant private sector investment, which must grow steadily to nearly $1.5 billion in 2050. This investment is profitable but requires clear policy commitments to providing private sector confidence in investing in carbon neutral actions.

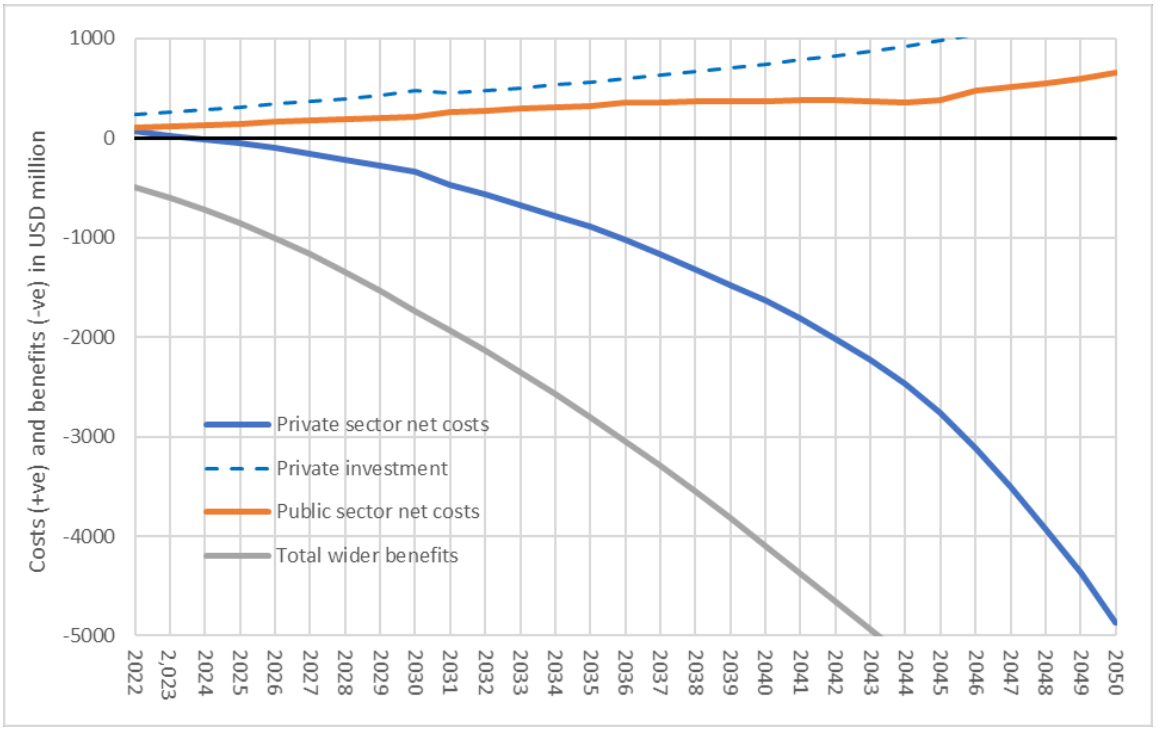


*Figure 16: Total costs and benefits of public and private capital and operating expenditures*

**Costs and benefits by sector:** Figure 14 shows the sectoral distribution of net costs and benefits. The economic impacts of actions in the agriculture, waste, and IPPU sectors are small. The overall costs are dominated by FOLU, with net costs in 2050 of about $1 billion. These costs are attributed to the FOLU sector but the largest element is the opportunity cost of foregoing income from the agricultural use of deforested land. The cost of foregoing timber sales from deforestation is also large. Direct forestry costs are significant but smaller than the opportunity costs associated with reduced deforestation. The benefits are dominated by energy and transportation, with net benefits of over $4 billion in 2050, driven largely by economic savings from energy efficiency plus reduced commuting costs associated with public transportation, renewable energy, lower haulage costs, and electric vehicles.

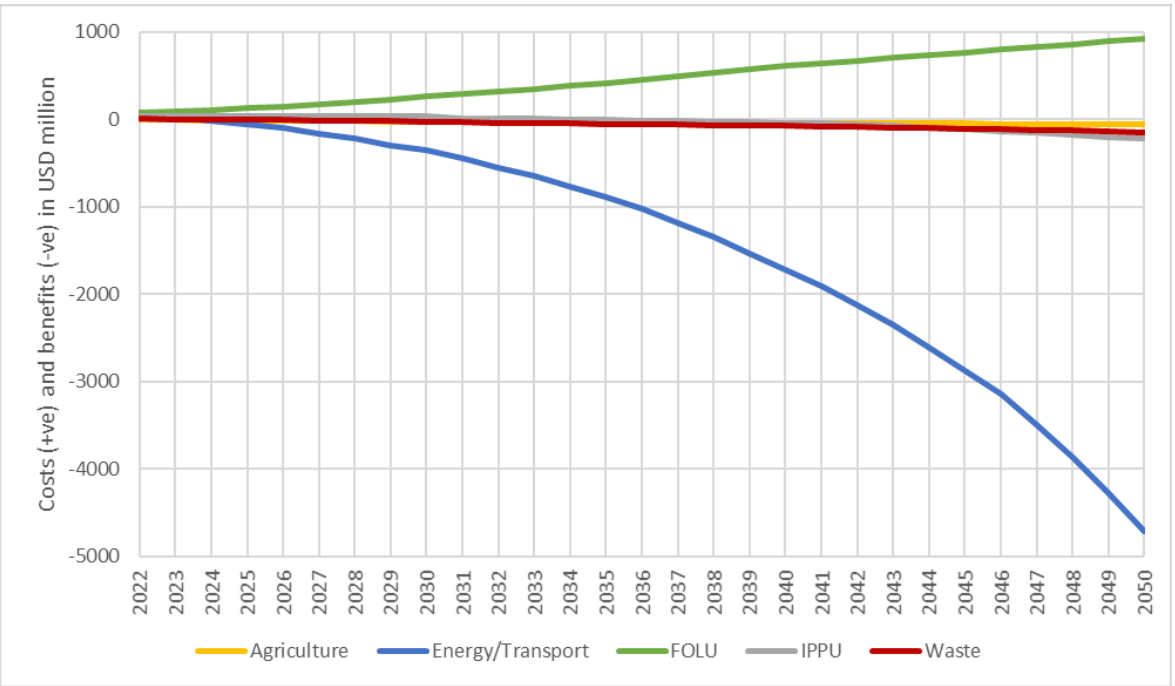


*Figure 14: Total costs and benefits by sector*

## 3.3. Public sector costs

Figure 15 shows public sector costs by sector, with substantial funding required in energy and transportation, FOLU, and IPPU. Mid-period funding in the energy sector relates largely to public transportation. The strong increase in the last decade is associated with investment in rail and haulage to support strong economic growth, and the loss of a fuel duty as electrification of transportation expands.

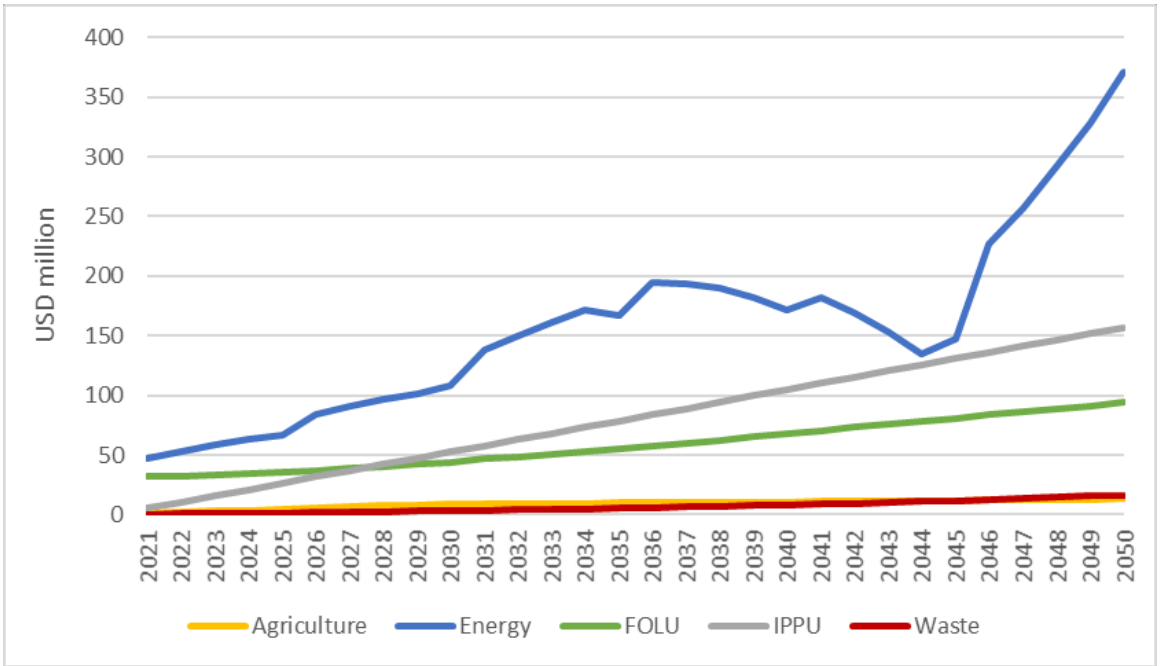


*Figure 15: Public sector costs by sector*

Figure 19 shows the breakdown of public expenditure requirements by key actions. The largest requirements are for operating expenditures in the energy and transportation sectors, which require over $350 million in funding in 2050, with large funding requirements for rail and haulage. The loss of a fuel tax is partially offset by gains from competitive renewable energy generation. Public transportation subsidies are initially high but the analysis assumes that these costs are increasingly offset through cost-recovery fare policies. Carbon capture and storage requires steadily increasing funding; no accounting is made for possible reductions in its costs.

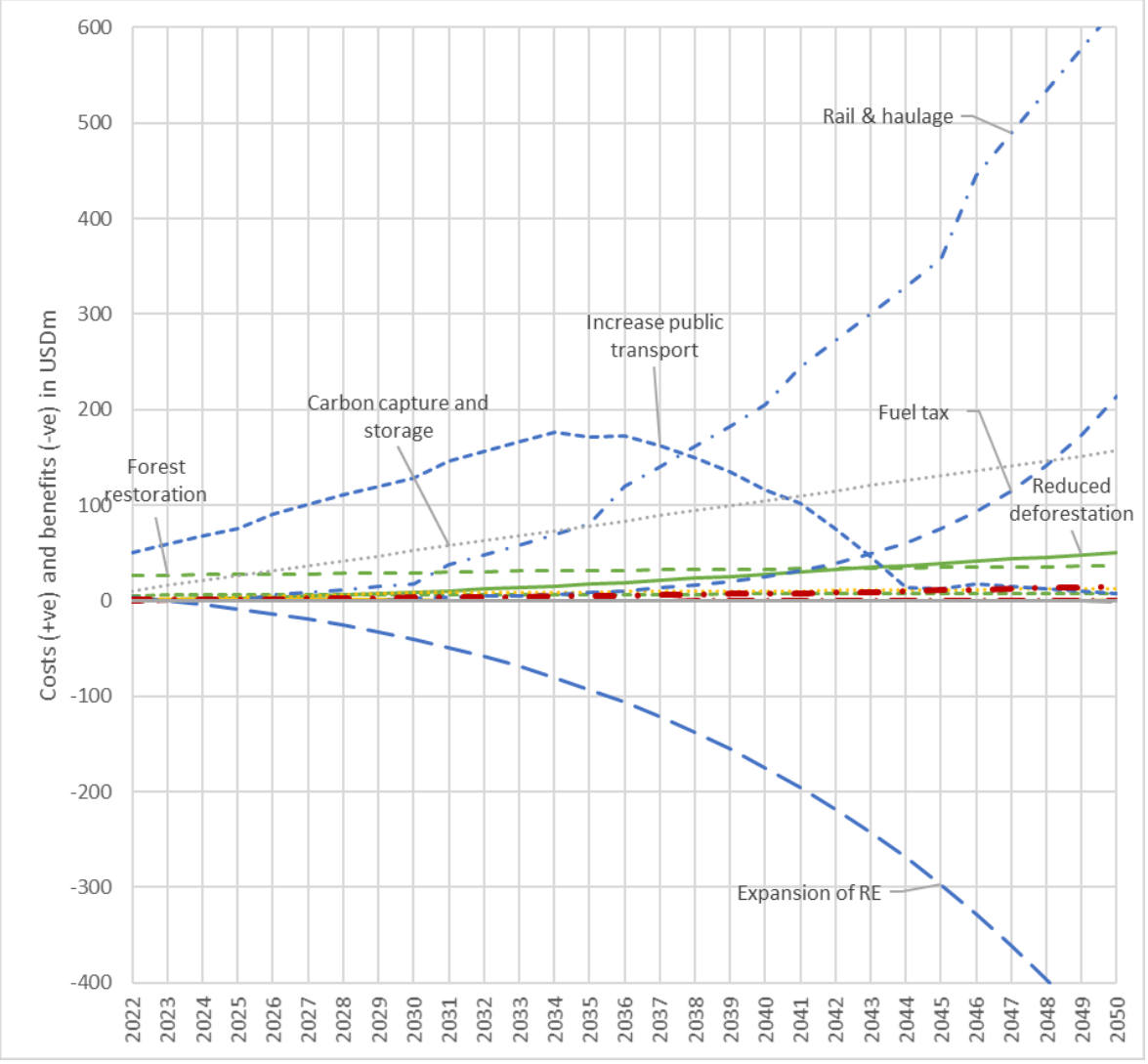


*Figure 19: Public sector costs by action*

There are smaller net costs in the forestry sector, mainly from lost forestry royalties but also from the cost of supporting reforestation, afforestation, improved forestry management, and restoration of degraded forest. The costs of public support average $17 million per year in the first 10 years of the LTS4CN. This is consistent with the REDD+ Investment Plan, which requires $16 million per year.

## 3.4. Implications for investment, economic growth, gender, and jobs

This section considers only the net economic benefits from LTS4CN actions, without taking into account the adaptation and wider social and environmental benefits, which are addressed in the next section.

Figure  presents the potential loss in GDP arising from climate change with no global commitment to carbon neutrality. This assessment comes from the CEGIM. It suggests that GDP in 2050 would be lower by over $15 billion or 10 percent of GDP if mitigation is limited to the levels assumed in the IPCC mid-range climate change scenarios.[10] If global commitments to carbon neutrality are realized, this will not eliminate all GDP losses; the extent of loss avoidance is unclear, however. Some losses arise because of emissions that have already taken place. Achieving carbon neutrality by 2050 would reduce cumulative new emissions by half (if reductions are achieved in a linear fashion), compared to a mitigation policy freezing emissions at current levels. If GDP losses from past emissions account for one third of the total loss, and global carbon neutrality halved remaining losses, GDP loss would fall by about $5 billion in 2050.

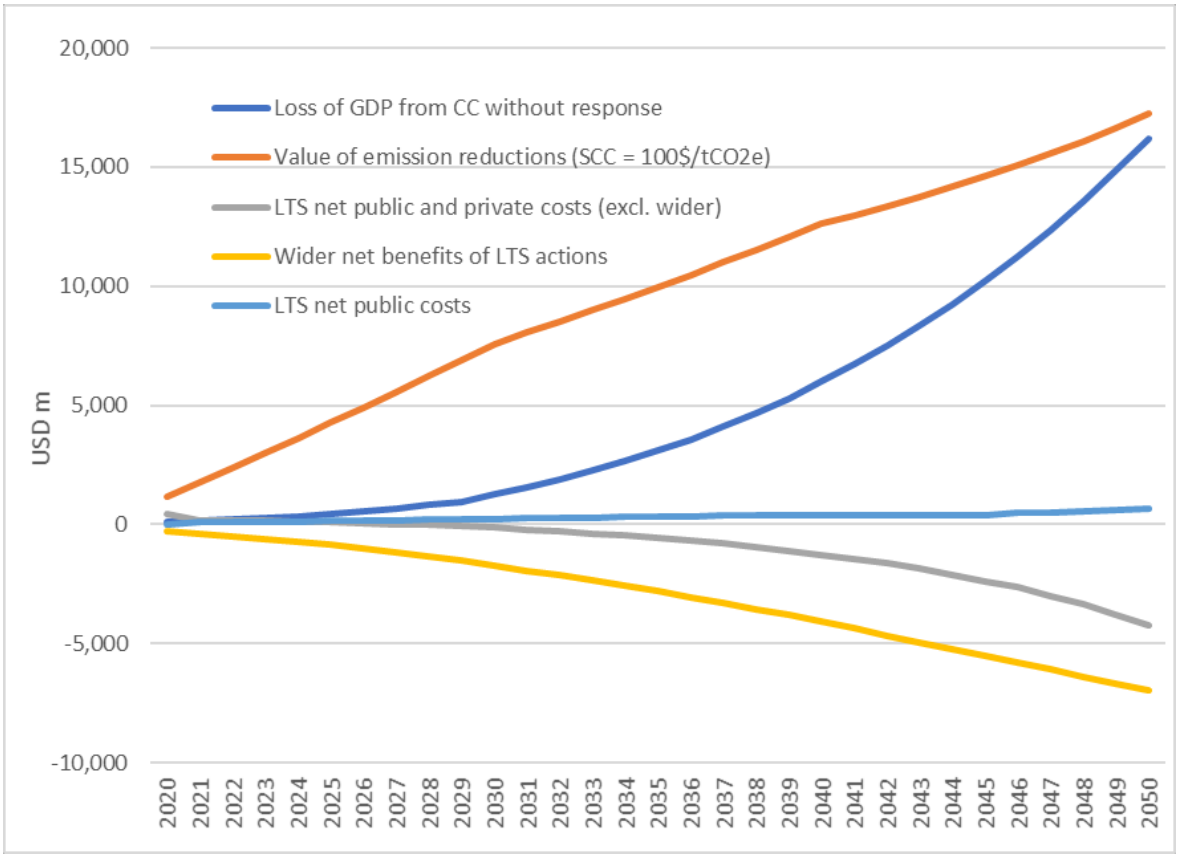


*Figure 20: Implications of LTS4CN for economic growth*

The assessment above considers only the effects of mitigation actions on reducing GDP loss arising from climate change. Economic analysis shows substantial net economic benefits from LTS4CN actions. It assumes that total annual public and private investment in these actions rises to $18.6 billion by 2050 and accounts for between 5-8 percent of total national investment

[10] For floods, droughts, rainfall variability and sea level rise, it used the A1 scenarios in the IPCC *Special Report on Extreme Events*, and for heat stress, the RCP4.5 scenarios in the IPCC *Fifth Assessment Report.*

over the period. The analysis suggests that net annual benefits from this investment would rise to over $6 billion by 2050, which implies an average rate of return on investment of 20-25 percent. In recent years, Cambodia has achieved high growth rates of over 7 percent of GDP with investment levels of about 25 percent of GDP, suggesting that routine non-LTS4CN investment be delivering rates of return on investment similar to those achieved by the LTS4CN investment. Although there is considerable uncertainty around the accuracy of available data, evidence suggests it would be possible to reallocate some domestic investment from routine development to LTS4CN actions without a significant loss of growth. The substantial economic gains from mitigation are thus achievable without significant net economic costs.

Based on available evidence, the average return on investment for routine development is about five percentage points higher than for LTS4CN investment, at about 28 percent compared to 20-25 percent. There would, therefore, be a modest reduction in growth from diverting funds from routine development to LTS4CN investment, before considering mitigation, adaptation, and wider benefits. Achieving the financing plan presented in the previous section would mean 26 percent of LTS4CN investment would be funded by international climate finance, without reducing domestic investment in routine development. This would roughly compensate for the difference in returns on investment. The scale of international funding envisaged in the financing plan is consistent with the argument that developing countries should be compensated for the net costs of their contribution to global mitigation.

The CEGIM analysis suggests that a package of adaptation measures could reduce losses and damages arising from climate change by 22 percent or about $3.3 billion.[11] If global carbon neutrality plans are implemented (worth about $5 billion to Cambodia in 2050) and Cambodia adopts the adaptation measures described in the CEGIM analysis (worth about $3.3 billion), the potential loss of GDP arising from climate change could be about 55 percent less than the $15 billion projected in the CEGIM analysis,[12] without significantly reducing growth from investment in the economy.

Figure  presents an estimate of the potential value of carbon emissions delivered by LTS4CN actions, if they are valued at the social cost of carbon of $100 per $tCO_2e$.[13] This analysis suggests larger reductions in the loss of GDP may be achievable, although given uncertainties around the appropriate value of the social cost of carbon, this comparison is useful mainly as a source of confidence that the LTS4CN economic analysis is not exaggerated.

**Labour and jobs:** The economic benefits from LTS4CN actions could take the form of either increased profits or increased income associated with new jobs and greater wages. Since the case studies reviewed in the economic analysis do not provide enough evidence to assess whether benefits come from profits or income, a detailed modelling of the impact on jobs and incomes is not possible. A first indication can be provided by using evidence in the Cambodia Social Accounting Matrix (SAM), which distinguishes between returns to income and capital for 26 sectors, including agriculture and forestry (56 percent to labour), manufacturing (60

[11] These adaptation measures are mostly different than the LTS4CN actions. The benefits are thus separate from the adaptation co-benefits from LTS4CN actions.
[12] The net economic benefits from the LTS4CN.
[13] The social cost of carbon is estimated by dividing the expected global loss of GDP arising from climate change by the emissions reductions required to avoid that loss. The Biden Administration in the United States of America is currently reviewing evidence on the social cost of carbon but it is expected to rise substantially from the level of $50 per $tCO_2e$ used in the Obama Administration to a level greater than $100 per $tCO_2e$.

percent to labour), and transportation/services (51 percent to labour), with a national average of 45 percent to labour. Statistics from the International Labour Organization (ILO) show average salaries in 21 sectors in 2019, with a national average of $266 per month and $173 per month for agriculture and forestry, $254 for manufacturing, $259 for energy, and $170 for water and sanitation.

Using these statistics, it is possible to estimate the number of jobs created by the economic benefits of each LTS4CN sector. The analysis does not count jobs created by actions that have net costs because the costs will be reflected in lower incomes elsewhere in the economy. For example, all FOLU actions do create jobs in forestry but some also involve substantial net costs. In particular, reducing deforestation generates some jobs, such as in enforcement, but it results in the loss of agricultural income from the inability to cultivate land that would otherwise have been converted into agriculture.

The analysis suggests that the direct economic benefits from LTS4CN actions would deliver 157,000 jobs by 2050, using the following assumptions:

- Only the LTS4CN actions that deliver net benefits are considered;
- The share of benefits obtained by labour is based on the SAM; and
- All sector salaries rise in line with the CEGIM projections for per capita GDP.

All of these jobs are in sectors with average incomes that are less than the national average, generating a net contribution to reducing equality. About 80 percent of the jobs are in the energy and transportation sector. Since it has wages only slightly below the national average, the net impact on inequality would be modest.

If resources for LTS4CN investment were used for routine development, outside the LTS4CN, and if they achieved returns similar to the average for Cambodia in recent years, total economic benefits would be slightly higher than direct benefits from LTS4CN actions. As a higher share of benefits would go to profits and average wages would be higher, the total number of jobs created would be slightly higher at about 183,000 in 2050, compared to 157,000 for LTS4CN investment.

Table below expands the analysis to include not only jobs created by the direct economic benefits from LTS4CN actions. When jobs from wider mitigation and adaptation benefits are added, LTS4CN actions generate 449,000 jobs in 2050, or 145% more than routine investment.

*Table 11: Jobs created by the LTS4CN compared to routine investment*

| | **LTS4CN investment** | | | | **Routine investment** |
|---|---|---|---|---|---|
| | **Direct benefits** | **Adaptation and wider benefits** | **Mitigation benefits*** | **Total** | |
| **Benefits in 2050 (millions of dollars)** | 5,539 | 6,971 | 5,398 | 17,907 | 7,758 |
| **Labour share (%)** | 51 | 45 | 45 | | 45 |
| **Average salary in 2050 (dollars per year)** | 18,172 | 19,074 | 19,074 | | 19,074 |
| **Jobs created in 2050 (hundreds of thousands)** | 157 | 164 | 127 | 449 | 183 |

Note: * Assumes one third of CEGIM loss in GDP from climate change is averted with global carbon neutrality by 2050.

**Impact on gender equality:** The impact of the LTS4CN on gender equality is difficult to assess without more detailed evidence on incomes in subsectors and the possibilities for designing actions to promote gender equality. An illustration of the potential impact, however, is provided by comparing the impact of reduced deforestation (the only action with net annual private sector costs) with the impact of energy efficiency (which delivers just over half of total annual private sector benefits). The costs from reduced deforestation involve loss of farm income, where women will be more affected than men because they account for 53 percent of agricultural labour. In contrast, benefits from energy efficiency in manufacturing are over twice the costs of deforestation, and women account for 67.5 percent of manufacturing labour. New jobs for women in manufacturing will be much better paid than those lost in agriculture. Table 2 presents the analysis and shows that the combined effect of the two LTS4CN actions will increase incomes by over $600 million in 2050 and create over 22,000 new jobs. Women will receive 77 percent of the net increase in income and 86 percent of the net increase in jobs.

*Table 12: Changes in jobs and income for men and women based on lower deforestation and greater energy efficiency in 2050*

| | **Lower deforestation** | | **Greater energy efficiency in manufacturing** | | **Total effect of both actions** | |
|---|---|---|---|---|---|---|
| | Women | Men | Women | Men | Women | Men |
| **Total benefits in 2050** | –784 | | 1,787 | | 1,003 | |
| **Labour share of value added (%)** | 56 | | 60 | | | |
| **Change in incomes** | –439 | | 1,072 | | 633 | |
| **Share of employment (%)** | 53.1 | 46.9 | 67.5 | 32.5 | | |
| **Change in gross income** | –233 | -206 | 724 | 348 | 491 | 143 |
| **Sector average income in 2050 (dollars per year)** | 11,342 | 13,332 | 18,215 | 18,855 | | |
| **Change in jobs** | –20,558 | -15,447 | 39,734 | 18,481 | 19,176 | 3,034 |

Sources: SAM for the labour share of value added and the ILO for sector incomes and sector average income, updated using CEGIM per capita incomes. The pathway model estimates 53 percent of energy efficiency benefits are in manufacturing. For more, see: ILO and Asian Development Bank, 2103, *Gender Equality in the Labor Market.*

The above analysis considers only the impacts on incomes and jobs from the direct economic costs and benefits of the two LTS4CN actions. There are three further ways in which the LTS4CN will affect gender equality.

- Actions have adaptation co-benefits. Since women are more vulnerable to climate change than men, they are likely to benefit more from adaptation;
- Actions have wider social and environmental benefits, mainly related to forestry (i.e., better health, non-timber incomes, and flood reduction). These will be shared by both men and women but will benefit women more because they are more engaged in activities linked to natural resources; and
- Finally, if the LTS4CN is matched by equivalent global reductions in emissions, there will be very large benefits from reduced economic losses and damages due to slower climate change. Women again will benefit more than men given their greater vulnerability to climate change.

## 3.5. Adaptation and wider social and environmental benefits

**Adaptation benefits:** A monetary value for adaptation benefits was estimated based on a classification system developed. It is assumed that a high classification will increase benefits

by 50 percent. This is because most adaptation benefits are associated with resilience to extreme and irregular rainfall patterns. The IPCC *Special Report on Extreme Events* suggests that the frequency of these events would roughly double by 2050 in Cambodia.[14] Therefore, the average increase over the period in benefits from a public action with high adaptation relevance is 50 percent, compared to 30 percent for a mid-level of relevance and 10 percent for low relevance.

**Wider social and environmental benefits:** Wider benefits are estimated based on a comprehensive literature review of case studies reporting on the valuation of social and environmental benefits. This review is summarized in the separate technical Annex. The evidence is patchy. While several studies attempt valuation, they often produce quite widely varying results.

Total wider social and environmental benefits are estimated to be worth more than the economic benefits, at nearly $7 billion in 2050. Over 90 percent of these benefits are associated with forestry and almost all the rest with energy efficiency. Key features of the wider benefits are as follows.

- Forestry delivers critical watershed benefits related to the retention of water in the soil. This reduces erosion, which decreases dam siltation and improves water quality. It also reduces downstream flooding. For established natural forests, these benefits are estimated at over $500 per hectare a year. Plantations and recovering forest areas also deliver watershed benefits but to a lesser degree.
- Forestry delivers important biodiversity benefits with studies suggesting that one-off loss of these benefits from deforestation amount to about $2,000 per hectare.
- The economic analysis includes only potential incomes from timber extraction. Wider benefits from tourism and non-timber forest products are also possible, with values of over $300 per hectare reported in various studies.
- The main wider benefits from energy and transportation relate to the health benefits from reduced pollution. Global studies provide some indications of the average national cost of pollution linked to emissions. When these are adjusted to reflect Cambodia's per capita income, they suggest an average of $4.6 per $tCO_2e$. Economic analysis uses this figure for power generation. Emissions from transportation are likely to have significantly higher health costs because people are much more exposed to concentrated levels of pollution.
- The Extended Cost Benefit Analysis case studies and international literature review provide some evidence for further specific wider benefits. Health benefits from electrification of cooking are about 10 times higher than average health benefits. Buses and trains cut the number of accidents. Waste actions reduce water pollution.

## 3.6. Benefits of adaptation for economic growth

### 3.6.1. Sector adaptation co-benefits analysis

An analysis of adaptation co-benefits looked at each sector and related mitigation actions in the LTS4CN. To measure impacts on the country and local levels, an assessment of relevance

[14] IPCC, 2012, Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change.

now and in the medium-term 2050 scenario was included. Some impacts that are not immediately relevant can become very significant with the progression of climate change.

It was assumed that extreme events become more frequent in line with the conclusions of the IPCC 2012 *Special Report on Extreme Events*. The report found that the frequency of most irregular climatic events (from floods to droughts to unseasonal rainfall) will roughly double by 2050. Exposure to climate change will be mainly through the changing frequency of extreme events and rainfall variability.

The results of the analysis are reported in the following tables by sector. A scale shows the expected impact of each measure (low, moderate, medium, high, and top). The last column indicates specific NDC actions related to proposed adaptation benefits.

### *Agriculture sector*

*Table 13: Adaptation co-benefits in the agriculture sector*

| No | Mitigation action | Adaptation co-benefit | Relevance (now) | Relevance (2050) | NDC action number |
|---|---|---|---|---|---|
| **1** | Less methane-intensive rice cultivars | Conservation of biodiversity and ecosystem services as part of an integral adaptation strategy to assist human communities facing the adverse effects of climate change. | Medium | High | 63 |
| | | Minimize the risks (drought, soil loss, etc.) during extreme climatic events by promoting resilient cropping systems. | High | High to top | 2 |
| **2** | Direct seeding practices | Reduced exposure to climate related extremes and slow onset events affecting agriculture and dependent livelihoods. | Medium | High | 2 |
| | | Support in suppressing opportunistic agricultural pests and invasive species favoured by higher temperature and humidity due to climate change. | Low | Medium | 2 |
| | | Introduction of innovative sustainable techniques in crop rotation to strengthen their life cycle, reducing the use of chemicals, water consumption and soil erosion. | High | High to top | 7 |
| **3** | Alternate wetting and drying | Increased crop breeding for greater heat and water tolerance as well as food security. | Medium | High | 7 |
| | | Drought preparedness increases adaptive capacity for water management in | High to top | Top | 85 |

| | | | | | |
|---|---|---|---|---|---|
| | | response to reduced levels of precipitation. | | | |
| | | Enable more consistent stream flows that can deliver irrigation water. | High to top | Top | 85 |
| | | Potential for scaled-up climate-resilient agricultural production through increased access to solar irrigation systems and other climate resilient practices. | Low | Medium | 85 |
| **4** | Daily spreading of manure and use of digesters | Reduced vulnerability to climate-related erosion in cropping systems. | Medium | High | 7 |
| **5** | Improved feed quality fodder management | Value addition can reduce sensitivity to climate extremes and changes in agriculture. | Medium | High | 11,13 |
| **6** | Promotion of organic fertilizers | Increased soil fertility, which can help farmers deal with increased temperatures and climate variability. | Medium | High | N/A |

### *Energy sector*

*Table 14: Adaptation co-benefits in the energy sector*

| No | Mitigation action | Adaptation co-benefit | Relevance (now) | Relevance (2050) | NDC action number |
|---|---|---|---|---|---|
| **1** | Building sector | Increased energy security and less reliance on primary energy imports, e.g., fuels, coal, etc. | Medium | High | 50,51 |
| | | Increased adaptive capacity and resources of local communities affected by climate change. | Medium | High | 50,51 |
| | | Improved ability and capacity of vulnerable populations to protect themselves during climatic events. | Medium | High | 50,51 |
| | | Better-insulated buildings reduce both energy consumption and the impact of climate change-induced heat waves. | Medium | High | 50,51 |
| **2** | Industry | Decreased stress on systems that supply needed goods and services, given the intensification of resource and energy use, in particular through energy efficiency actions. | High | High to top | N/A |
| | | Through energy efficiency, improved insulation moderates internal temperatures during extreme heat/cold events. | Medium | High | 39 |
| | | Potential reduction in heat island effect/internal heating and cooling load from panel shading. | Low | Medium | 39 |

| No | Mitigation action | Adaptation co-benefit | Relevance (now) | Relevance (2050) | NDC action number |
|---|---|---|---|---|---|
| **3** | Transportation | Increased use of public transportation can provide additional transportation options and reduce redundancy in transportation systems during emergency events. | Low | Medium | 56 |
| | | Electric vehicles as additional emergency transportation for large populations in the event of evacuations or other major climatic events. | Low | Medium | 56 |
| | | Electric vehicles can potentially be utilized as back-up batteries in emergency situations. | Low | Medium | 56 |
| **4** | Power generation | Reduction of exposure to fluctuating fossil fuel costs and escalating carbon costs for vulnerable populations disproportionately impacted by climate change. | Medium | High | 24,25 |
| | | Facilitation of inclusiveness within the energy transition as a major pillar of adaptation (distributed generation, local renewable producers). | Low | Medium | 24, 25 |
| **5** | Biomass supply | Charcoal forest fire prevention and biodiversity protection since fires become more common with higher temperatures and longer dry spells. By limiting onsite burns of biomass material, it could be repurposed as an energy input. | Medium | High | 63 |

### *FOLU sector*

*Table 15: Adaptation co-benefits in the FOLU sector*

| No | Mitigation action | Adaptation co-benefit | Relevance (now) | Relevance (2050) | NDC action number |
|---|---|---|---|---|---|
| **1** | Stop deforestation | Increased forest resilience to climate change and reduced vulnerability of local populations. | High | High to top | 63 |
| | | Preservation of natural assets as a source of economic returns in the long run and reduced future expenditure to mitigate adverse events. | Medium | High | 63 |
| | | Prevent soil erosion and reduce flooding risks. | High | High to top | 63 |
| | | Reduced risks from landslides. | High | High to top | 63 |
| | | Favours water retention, moderate evapotranspiration and river restoration. | Medium | High | 63 |

| No | Mitigation action | Adaptation co-benefit | Relevance (now) | Relevance (2050) | NDC action number |
|---|---|---|---|---|---|
| | | Preserving natural corridors enables species migration and supports the maintenance of ecosystem and genetic diversity. | Low | Medium | 63 |
| | | Reduced heat stress and animal mortality. | Low | Medium | 63 |
| | | Increased species composition (e.g., the mix of hardwood and softwood species), age structure and harvest regime, and reduction of species emigration and extinctions. | Medium | High | 63 |
| | | Avoiding biotic disturbances such as the spread of pests and pathogens favored by climate change, while increasing connectivity in ecological networks. | Low | Medium | 63 |
| **2** | High/Middle/ Low sequestration forest | Improved forest management and protection and the development of sustainable ecosystem services, which can result in avoided deforestation or reforestation. | High | High to top | 63 |
| | | Conserving water in natural systems to alleviate the effect of droughts or prevent floods. | High | High to top | 63, 35 |
| **3** | Agroforestry | Ecosystem protection through the restoration of natural habitats affected by climate change; restored hydrological balance in river basins. | High | High to top | 1, 4 |
| | | Agroforestry can underpin poverty reduction and improve food availability for marginal rural communities more affected by climate change. | Medium | High | 1,4 |
| | | Increased filtering of stormwater and improved air quality assisting in adapting to climate change. | Medium | High | 1,4 |
| | | Maintaining groundwater and surface water quality and quantity; reducing and delaying flood flows. | High | High to top | 1,4 |

### *IPPU sector*

*Table 16: Adaptation co-benefits in the IPPU sector*

| No | Mitigation action | Adaptation co-benefit | Relevance (now) | Relevance (2050) | NDC action number |
|---|---|---|---|---|---|
| **1** | Clinker substitution | New materials can help to prevent overheating in warmer climates, keeping buildings cool when temperatures rise due to climate change. | Low | Medium | N/A |
| | | Using several products for clinker substitution, such as coal ash power, would reduce waste and land needed for disposal. | Medium | High | N/A |
| | | Replacing clinker with industrial waste or by-products prevents such waste ending up in landfills. | Low | Medium | N/A |
| ***2*** | Carbon capture and storage | Increased range of available adaptation options as well as their effectiveness in reducing or avoiding risk from increasing rates or magnitudes of climate change. | Low | Medium | N/A |
| **3** | Introduce alternatives for cement | Promoting the use of locally available mineral resources contributes to energy efficiency in buildings given thermal mass, fire resistance and durability. | Low | Medium | N/A |
| | | The use of alternative raw materials will reduce the use of primary raw materials whose availability can decline through climate change. | Medium | High | N/A |
| **4** | Use of substitutes for ozone-depleting substances (i.e., F-gases) | N/A | N/A | N/A | N/A |
| **5** | Promote sustainable energy practices in manufacturing | Increased energy security and less reliance on energy imports | Medium | High | N/A |
| | | Improved insulation moderates internal temperatures during extreme heat/cold events | Medium | High | N/A |
| | | Increased stakeholder awareness (building designers, users and owners) about risks and potential impacts on the environment posed by variable weather patterns and observed and projected climate changes. | Medium | High | N/A |
| **6** | Climate-friendly cooling of public sector buildings | Reduction of exposure to fluctuating fossil fuel costs and escalating carbon costs for vulnerable populations | High | High to top | N/A |

| No | Mitigation action | Adaptation co-benefit | Relevance (now) | Relevance (2050) | NDC action number |
|---|---|---|---|---|---|
| | | disproportionately impacted by climate change. | | | |
| | | Large-scale public-private risk reduction and economic diversification through government insurance for the non-diversifiable portion of risk. | Low | Medium | N/A |

### *Waste sector*

*Table 17: Adaptation co-benefits in the waste sector*

| No | Mitigation action | Adaptation co-benefit | Relevance (now) | Relevance (2050) | NDC action number |
|---|---|---|---|---|---|
| **1** | Solid waste disposal | Waste management prevents surface and groundwater contamination from toxic wastes that is higher in periods of intensive rain. | Low | Medium | 84 |
| | | Biogas and fertilizers from waste can increase agricultural yields that may decline due to climate change. | Medium | High | 8 |
| | | Biogas can increase energy security and reduce reliance on energy imports. | Medium | High | N/A |
| | | Biogas can reduce the exposure to fluctuating fossil fuel costs and escalating carbon costs for vulnerable populations disproportionately impacted by climate change. | Medium | High | N/A |
| ***2*** | Biological treatment of solid waste | Reduced soil erosion, which can otherwise be higher during periods of intense rain that will become more common due to climate change. | High | High to top | N/A |
| | | Improved crop yields through using compost. | Medium | High | 8 |
| | | Compost can increase soil fertility and replenish organic matter and nutrients. | High | High to top | N/A |
| | | Improved moisture retention of soil (resulting in lower irrigation requirements). | Medium | High | N/A |
| **3** | Incineration and open burning of waste | Improved soil conditions in areas degraded by climate change and used for waste burning. | Low | Medium | N/A |
| | | Benefits from energy production (see Action 1). | Medium | High | N/A |

| No | Mitigation action | Adaptation co-benefit | Relevance (now) | Relevance (2050) | NDC action number |
|---|---|---|---|---|---|
| **4** | Wastewater treatment and discharge | Adaptive water management in waste treatment can help adjust to uncertain hydrological changes due to climate change. | Medium | High | 82 |
| | | Adaptation benefits from compost production (see Action 2). | Medium | High | N/A |

# 4. Governance, Measurement, Reporting and Verification

## 4.1. Governance structure

The institutional arrangements for implementing the LTS4CN build on existing national coordination arrangements. The roles and responsibilities of each stakeholder are presented in Table 18.

*Table 18: Roles and responsibilities of stakeholders*

| Stakeholder | Roles and functions in LTS4CN implementation |
|---|---|
| **National Council for Sustainable Development** | Coordination and integration<br>Capacity building and knowledge management<br>Stakeholder engagement |
| **Ministry of Planning, Ministry of Economy and Finance** | Support to the integration of the LTS4CN implementation at national and subnational planning and budgeting<br>Support to MRV development and implementation |
| **Sector-lead ministries/government institutions** | LTS4CN planning and implementation in respective sectors<br>Provision of information to the National Council for Sustainable Development |
| **Non-governmental organizations** | LTS4CN implementation<br>Provision of information<br>Provision of support<br>Engagement in policymaking<br>Representation of vulnerable groups |
| **Private/finance sector** | LTS4CN implementation<br>Engagement in policymaking<br>Provision of information |
| **Development partners** | Provision of support<br>Engagement in policymaking |
| **Academia** | Provision of research, development, innovation and information<br>Engagement in policymaking |

Stakeholders are represented in the following organogram.

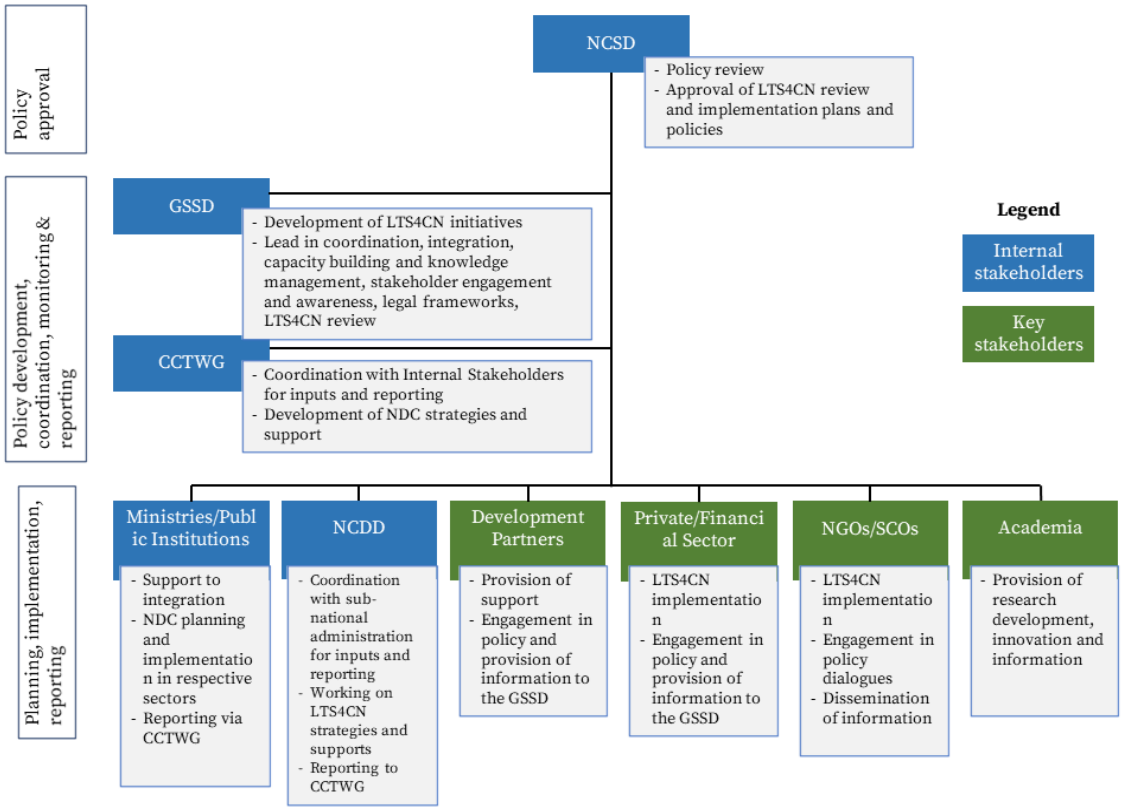


*Figure 21: Stakeholder roles and responsibilities*

## 4.2. MRV indicators and tracking

### 4.2.1. MRV framework

MRV helps transparently demonstrate progress in implementing the LTS4CN in line with the targets of Cambodia's Updated NDC.

Cambodia has developed an integrated and detailed MRV system for her updated NDC that comprises tracking and reporting on progress towards adaptation and mitigation, finance received, and required capacity support. The system assists in the coordination of NDC implementation, provides a collective and easy way to update progress made, serves as an effective communication and engagement tool, and provides access to all information relevant to reporting under the Paris Agreement. In developing the system, particular attention was paid to integrating cross-cutting issues in the tracking, such as those related to youth, gender, and private sector engagement.

The MRV framework for the LTS4CN will build on existing government systems, while strengthening capacity and data collection capability where possible. It will be integrated into the online NDC tracking system with reporting conducted in parallel. The long-term process will be tracked with specific sectoral headline indicators (Table 19) and results indicators that will be selected later.

*Table 19: Main sectoral headline indicators*

| Sector | Indicator | Frequency |
|---|---|---|
| **Waste** | | |
| | Total GHGs emissions from the waste sector ($MtCO_2e$): solid waste disposal, biological treatment, open burning, wastewater | Annual |
| | Percentage of emissions reduction by the waste sector against BAU: solid waste disposal, biological treatment, open burning, wastewater | Annual |
| **Agriculture** | | |
| | Total emissions ($MtCO_2e$) from the agriculture sector | Annual |
| | Percentage of emissions reduction by the agriculture sector against BAU | Annual |
| **IPPU** | | |
| | Total emissions ($MtCO_2e$) from the IPPU sector | Annual |
| | Percentage of emissions reductions by the IPPU against BAU | Annual |
| **Energy** | | |
| | Total emissions from the energy sector ($MtCO_2e$) | Annual |
| | Percentage of emissions reductions by the energy sector against BAU | Annual |
| **FOLU** | | |
| | Total emissions from the FOLU sector ($MtCO_2e$) | Annual |
| | Percentage of emissions reductions by the FOLU sector against BAU | Annual |
| **TOTAL** | | |
| | Total emissions ($MtCO_2e$) for waste, agriculture, IPPU, energy, and FOLU | Annual |
| | Percentage of emissions reductions (waste, agriculture, IPPU, energy, and FOLU) | Annual |

### 4.2.2. Reporting responsibility

The LTS4CN will likely be reviewed every five years in line with the framework for updating NDCs. This will ensure the transparency, accuracy, and comparability of information on emissions reductions leading towards carbon neutrality by 2050.

Relevant sector leads and ministries will contribute to tracking LTS4CN implementation. They will need to communicate outcomes to the National Council for Sustainable Development to support national reporting. The Council is responsible for collecting and submitting Cambodia's national reporting related to the Paris Agreement.