Nepal's
Long-term Strategy for Net-zero Emissions

Government of Nepal

Kathmandu

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ACRONYMS

$	U.S. dollars
AFOLU	Agriculture, Forestry, and Other Land Use
AR5	Fifth Assessment Report
CCUS	carbon dioxide capture, utilization and storage
CH4	methane
CO	carbon monooxide
CO2	carbon dioxide
COP	Conference of the Parties
CSO	civil society organisations
GDP	gross domestic product
GHG	greenhouse gas
GON	Government of Nepal
GRID	green, resilient, and inclusive development
HFCs	hydrofluorocarbons
IMCCCC	Inter-Ministerial Climate Change Coordination Committee
INC	Initial National Communication
IPCC	Intergovernmental Panel on Climate Change
IPPU	industrial processes and product use
LDC	Least Developed Countries
LULUCF	land use, land use change, and forestry
LEAP	Low Emissions Analysis Platform
LPG	liquified petroleum gas
LTS	Long-term Strategy
MoEWRI	Ministry of Energy, Water Resources and Irrigation
MOFE	Ministry of Forests and Environment
mMt	million metric tonnes
MRV	monitoring, reporting and verification
N20	nitrous oxide
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NOx	nitrous oxides
NMVOC	non-methane volatile organic compound
NCCP	National Climate Change Policy
NDC	Nationally Determined Contribution
NPC	National Planning Comission
PFCs	perfluorocarbons
PA	Paris Agreement
PIF	Policy and Institutions Facility
REDD	Reducing Emissions from Deforestation and Forest Degradation
SDGs	Sustainable Development Goals
SF6	sulphur hexafluoride
SNC	Second National Communication
SO2	organic compound
TNC	Third National Communication
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
VRE	variable renewable energy
WAM	with additional measures
WEM	with existing measures

Executive Summary

Nepal is committed to accelerating climate action whilst adhering to the principle of shared but differentiated responsibilities and respective capabilities towards the implementation of the Paris Agreement as per national circumstances. Nepal's goal is to achieve net zero emissions from 2020-2030 and after a period of very low emissions to full net zero by 2045. Nepal would also like to gain recognition for its mitigation contributions beyond its border through clean energy trade. Nepal's Long Term Strategy envisions bold policymaking, social transformation, and technological advancements that will lead to a carbon-neutral, inclusive, and climate-resilient future.

Nepal's total carbon dioxide (CO2) emissions in 2019 was 23 mMtCO2 in the reference scenario. This figure is expected to rise to 34 mMtCO2 in 2030 and 79 mMtCO2 in 2050. While non-energy-related emissions accounted for 46 per cent of net CO2 emissions in 2019 the energy sector accounted for 54 per cent. In the reference scenario, non-energy emissions would gradually decrease to 32 per cent of total emissions by 2050. Land Use, Land Use Change, and Forestry (LULUCF) CO2 emissions were estimated to be 8 mMtCO2 in 2019 and are expected to rise to 17 mMtCO2 by 2050.

In the **with existing measures (WEM)** scenario, the net CO2 emissions will be reduced by 30 mMtCO2 in 2030 and 50 mMtCO2 in 2050. In this scenario, the energy sector will be one of the most important contributors to emission reductions. LULUCF will contribute significantly to carbon removal in the first 10 years. However, the sink potential of LULUCF will decrease overtime per the assumptions used in this scenario. As a result, after 2030, net carbon emissions will rise at an annual rate of 11 per cent.

In the additional measures (WAM) scenario ambitious interventions in the energy sector combined with ongoing and additional carbon removal interventions indicate that Nepal's net CO_2 emissions will be lower than 'zero' in the period 2020 to 2030, then hovering around 'zero' throughout 2035 to 2045. Sequestration increases from 2045 onwards reaching -5.7 mMT in 2050.

Comparison of different scenarios shows that the country's carbon emission reduction potential is very high, and with interventions of strategic measures, it is capable of maintaining very low emissions levels. It is even possible, with ambitious, conditional targets, to achieve negative carbon emissions by 2050, whilst reaching net-zero before or by 2045.

The sectoral strategy includes the following:

1. **Energy:** Nepal uses energy in agriculture, transportation, industry, and commercial and residential sectors. As per the 2019 baseline assessment, residential, transportation, industrial, commercial, and agricultural energy use contributes to emissions in descending order. Thus, to reduce carbon emissions in the residential sector the use of liquified petroleum gas (LPG) must be reduced and more electrical appliances e.g. electric cooking and biogas must be used. The transportation sector will need to transition to zero-emission transportation for intercity, intracity, and freight travel across public and private modes. The brick sector needs to shift to zig-zag and tunnel kilns technologies, and then full electric heating. The use of energy-efficient technologies will also help in reducing emissions in the agriculture sector. The main strategy is to power the industrial, commercial, and agricultural sectors with renewable energy and hydrogen technologies, which Nepal has in abundance. Furthermore, in the power generation sector, all electricity will be generated from renewable sources, primarily hydropower plants, as well as solar PV. Refer to Table 2 for the strategy in the energy sector.

2. **IPPU**: Nepal's emissions from industrial processes and product uses are currently low. But with the expected growth forecast, Nepal will switch to renewable energy and waste-related fuel, and raw materials such as limestone for the cement industry.

Additionally, Nepal will explore the potential for carbon capture and storage, beyond that possible through the forest sector.

3. **Agriculutre, Forestry, and Other Land Use (AFOLU)**: In the agriculture sector, Nepal must switch to better cultivation practices, rice intensification system, better manure management, soil organic matter enrichment, soil management practices such as low soil tillage, adaptive and resilient varieties, and breeds, expanded adoption of controlled release of stabilized fertilizers, better enteric fermentation processes, and promote agroforestry and other sustainable agriculture systems.

4. **For Forestry and Other and Land use:** Nepal must increase and maintain its forest cover, increase afforestation and achieve net-zero deforestation, adopt measures to decrease forest fire incidents, scale-up sustainable forest management, and agroforestry, and private forestry practices, promote energy-efficient technologies and improve the monitoring and database systems. Refer to Table 4 for a strategy for the forestry sector.

5. **Waste**: To reduce waste emissions from solid waste disposal, open burning of waste, and waste-water treatments technologies like methane gas recovery, incineration of waste for heat and power generation, and methane generation from anaerobic digester in wastewater treatment must be promoted.

6. **Energy Trade:** Significant emissions reductions can be achieved outside of Nepal through Hydro and Solar power exports. These have been included to illustrate the potential, whilst acknowledging that this does not form part of the current National emissions regime.

Nepal's Long-Term Strategy setups up ambitious sector strategies and its implementation will be guided by transformative policy and legal strategies identified for each sector, clear institutional mechanisms, clarity in roles and responsibilities of all three spheres of Nepal's governments, engagement of the private sector, and other agencies, enhanced stakeholder collaboration, adequate financial resources, and a robust Monitoring, Reporting, and Verification (MRV) mechanism. Nepal's ambition-related actions necessitate significant financial resources, upon which its ambition is conditional.

Investments: Significant investment will be required to achieve these ambitious GHG mitigations and net abatement targets over the implementation period. Demand-side investment, transformative investments, and non-energy sector investment, such as forestry, are all included, (production costs of green hydrogen are excluded).

The required costs are estimated in constant US Dollar prices (2000 AD) for all scenarios. The total costs of the sectors considered in the Reference scenario are estimated to be 4.2 billion dollars from 2021 to 2030, 7 billion dollars from 2031 to 2040, and 17.5 billion dollars from 2041 to 2050. In the WEM scenario, the total costs of the sectors considered are estimated to be 42.8 billion USD from 2021 to 2030, 34.4 billion USD from 2031 to 2040, and 56.2 billion USD from 2041 to 2050. In the WAM scenario, the total costs of the sectors considered are estimated to be 46.4 billion USD from 2021 to 2030, 53.4 billion USD from 2031 to 2040, and 96.3 billion USD from 2041 to 2050.

Linkages with other sectors: The ambition of Nepal to minimise emissions and achieve net-zero emissions by 2045 has clear links to the achievement of the Sustainable Development Goals (SDGs) by 2030, and implementation of Nepal's Climate Change Policy (2019), REDD + strategy, and NAP for 2030 & 2050. The SDGs include both direct and indirect targets and indicators aimed at achieving low-carbon, climate-resilient development in Nepal. Climate action has been fully integrated into the SDGs as a key means of achieving its sectoral goals of sustainable development. Another important aspect is to consider the gender and inclusion issues whilst designing and implementing the mitigation strategies.

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Chapter One: Background and Context

1.1. International context

At the Rio Earth Summit in 1992, world leaders agreed to establish international environmental and development activities that would guide international cooperation and development policy for all countries[1]. Since then, developed and developing countries have actively engaged in environmental discussions and dialogue. At the global level, it was shown that human activity had altered the composition of the global atmosphere, resulting in extreme climatic variability which alerted countries to act on reducing anthropogenic GHG emissions after the post-industrial phase. Climate change is now regarded as one of the existential crises that human civilization is confronted with. The United Nations Framework Convention on Climate Change (UNFCCC) recognizes these global contexts and urges countries to take responsibility to combat dangerous human interference with the climate system by stabilizing GHG concentrations in the atmosphere.

The Paris Agreement, signed in 2015, established legally binding international climate goals to keep global temperature rises to 1.5 degrees Celsius above pre-industrial levels. All Parties should strive to formulate and communicate long-term low GHG development strategies, mindful of Article 2, taking into account their common but differentiated responsibilities and respective capabilities, in light of different national circumstances, as outlined in Article 4, paragraph 19, of the Paris Agreement. By decision 1/CP 21, paragraph 35, the Conference of the Parties (COP) invited Parties to submit long-term low greenhouse gas emission development strategies to the UNFCCC secretariat by 2020. Countries will determine the scope of the long-term strategy (LTS) in terms of sectoral greenhouse gas (GHG) emissions by formulating appropriate policies, measures, and financial pathways that can lead to meeting emission reduction targets. Nationally Determined Contributions (NDCs) are short-term national climate action plans that serve as the foundation for countries to achieve the long-term mitigation and adaptation goals envisioned on the LTS.

1.2. National context

Nepal is among the most vulnerable countries to climate change and is at high risk due to the country's fragile topography, climate-sensitive and subsistence livelihoods of the people, and their low adaptive capacity. Nepal's gross domestic product (GDP) is highly dependent on climate-sensitive sectors such as agriculture, water, energy, and tourism. With these ongoing climate change impacts, the national GDP is likely to suffer in the future. The economy of Nepal is experiencing uneven GDP growth, hovering between 1 %and 8 % per year. Currently, the agriculture sector contributes significantly to the national GDP (27 per cent of total contribution). With a 7.3 % GDP growth rate over the last three years (2017 to 2019), Nepal has made significant progress. However, due to the ongoing COVID-19 pandemic, which has a widespread impact on the national economy, GDP growth is has slowed dramatically in 2020 and 2021.

Despite its negligible emissions, Nepal is committed to accelerating climate action while adhering to the Paris Agreement's common but differentiated responsibilities and respective capabilities. Nepal submitted its first NDC to the UNFCCC Secretariat in 2016 and the second one in 2020 comprising targets up to 2030, both with a clear national climate action plan. As a result, based on recent reports from the Intergovernmental Panel on Climate Change (IPCC) and other scientific evidence, the country is committed to its long-term climate goals. Nepal is

1. [1] United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, 3-14 June 1992 | United Nations

systematically addressing the issue of climate change, with a commitment to keeping emissions to a very low/zero level until achieving sustainable net-zero emissions in 2045.

1.3. National policy initiatives

The government of Nepal has developed legal and institutional mechanisms to implement long-term goals as agreed in the Paris Agreements. The Environment Protection Act (2019), National Climate Change Policy (2019), Climate Resilient Planning and Budgeting Guideline (2019), Disaster Risk Reduction and Management Act (2017) and Regulation (2019), GESI and Climate Change Strategy and Action Plan (2019), National Adaptation Programme of Action (NAPA), National Reducing Emissions from Deforestation and Forest Degradation (REDD+) Strategy (2018), Sectoral Policies (forestry, energy, industry, transport, agriculture), the first and second NDCs, national communications, Sustainable Development Goals Strategy, Nepal Energy Strategy (2013), National Energy Efficiency Strategy (2018), sectoral long-term strategies, white papers, and the 15th five-year plan provide policy directives for Nepal to enhance resilience and adopt low-carbon development pathways. Some of the specific documents are explained below.

1.3.1. National Climate Change Policy 2019

Nepal's National Climate Change Policy (NCCP) aims to contribute to socio-economic prosperity by building climate resilient society. One of the major objectives of the policy is to promote a green economy by adopting the concept of low carbon emission development. It has developed policies, strategies, and guidelines in eight major sectors and four cross-cutting sectors.

The thematic areas are:

- Agriculture and Food Security
- Forests, Biodiversity, and Watershed Conservation
- Water Resources and Energy
- Rural and Urban Settlements
- Industry, Transport and Physical Infrastructure
- Tourism, Natural and Cultural Heritage
- Health, Drinking Water, and Sanitation
- Disaster Risk Reduction and Management.

The cross-cutting areas are:

- Gender Equality and Social Inclusion (GESI), Livelihoods and Good Governance
- Awareness Raising and Capacity Building
- Research, Technology Development, and Extension
- Climate Finance Management

1.3.2. Second Nationally Determined Contributions

In December 2020, the Government of Nepal (GON) submitted its second NDC for the period 2021-2030, in accordance with Articles 4.2 and 4.11 of the Paris Agreement, as well as Decision 1/CP.21 paragraphs 23 and 24, and other relevant Paris Agreement (PA) provisions. The 2020 NDC for the first time sets a vision to achieve net zero greenhouse emission by 2050. The NDC considers the principle of common but differentiated responsibilities and respective capabilities in light of national circumstances. The NDC has also established quantifiable activity targets as well as policy targets in key sectors. The second NDC has set the following targets on key sectors.

a) Energy: By 2030, increase clean energy generation to 15,000 MW, with 5-10 per cent coming from mini- and micro-hydropower plants, solar panels, wind, and bio-energy, ensuring 15 per cent of total energy demand is met by clean energy sources. The unconditional target is 5,000 MW.
b) Transport: i) In 2025, electric vehicles (e-vehicles) will account for 25 per cent of all private passenger vehicle sales (including two-wheelers) and 20 per cent of all four-wheeler public passenger vehicle sales (excluding electric rickshaws and electric three-wheelers). ii) Increase e-vehicle sales to 90 percent of all private passenger vehicle sales (including two-wheelers) and 60 percent of all four-wheeler public passenger vehicle sales by 2030. (excluding electric-rickshaws and electric three-wheelers). iii) Develop a 200-kilometer electric rail network by 2030 to support public transportation and mass transportation of goods.
c) Clean cooking/Residential cooking: The goal is to install 500,000 improved cooking stoves, primarily in rural areas, and an additional 200,000 household biogas plants and 500 large scale biogas plants (institutional/industrial/municipal/community) by 2025. ii) By 2030, ensure that electric stoves are used as the primary mode of cooking in 25 per cent of households.
d) AFLOU: i) By 2030, 45 per cent of the total area of the country will be under forest cover (including other wooded lands, which will be limited to less than 4 per cent); ii) Half (50 per cent) of the Terai and Inner Terai forests, as well as 25 per cent of the middle hills and mountain forests, will be managed sustainably, including through the use of REDD+ funding.
e) Waste: By 2025, 380 million litres of wastewater will be treated per day and 60,000 cubic metres of faecal sludge will be managed. When compared to BAU, these two activities will save approximately 258 Gg CO2 eq.

The second NDC includes policy targets in each section that are well aligned with GON's 15th five-year plan, relevant sectoral policies and strategies, climate change policy, and other national documents. GESI has also been incorporated into Nepal's second NDC, ensuring meaningful participation of women, indigenous communities, and youths throughout the NDC implementation process.

It is estimated that meeting Nepal's NDC conditional mitigation targets will cost U.S. dollars ($) 25 billion. The cost of meeting the NDC's unconditional targets is estimated to be $3.4 billion. This estimate includes only activity-based targets. The cost of implementing the adaptation component will be specified in the upcoming National Adaptation Plan (NAP).

1.3.3. Third National Communication

Nepal has submitted its Third National Communication (TNC) to the UNFCCC. This TNC builds on Nepal's previous national communications, the Initial National Communication (INC) in 2004 and the Second National Communication (SNC) in 2014. It includes the most recent information on the country's national situation, GHG inventory (for the base year 2010/11), GHG mitigation assessment, vulnerability and adaptation assessment, and policies, plans, programs, and activities designed or implemented to address these issues.

For the base year 2010/2011, Nepal's GHG inventory accounts for emissions by source and removal by sinks. The inventory takes into account direct GHGs [carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF6)] as well as indirect GHGs [carbon monoxide (CO), Nitrous oxides (NOx), Non-Methane Volatile Organic Compound (NMVOC), Sulfur Dioxide (SO_2).

The inventory was conducted in accordance with the 2006 IPCC Guidelines for Reporting National Communications from Non-Annex 1 Parties and other relevant documents, primarily using the Tier 1 approach. The inventory tracked emissions and removals from four sectors: energy, IPPU, AFOLU, and waste. According to the TNC report, Nepal's net GHG emissions in 2011 were estimated to be 28,166 MtCO2-eq. This represents a significant increase over

the baseline year's emissions (13,447 MtCO2-eq). The inventory results were also used to develop trends in emissions dating back to 1990 and projecting to 2030.

1.3.4. National Adaptation Plan (NAP)

According to Articles 7.10 and 7.11 of the Paris Agreement, Nepal will submit an adaptation communication containing its priorities, implementation and support needs, plans, and actions via the NAP. The government is currently developing a NAP to identify medium- and long-term climate-sensitive sectoral adaptation options for 2030 and 2050. The NAP will outline Nepal's contribution to meeting the Paris Agreement's adaptation goals and the necessary means of implementation and financing. The NAP is being developed to strengthen a country-led, gender-sensitive, participatory, and fully transparent approach to reducing climate risks and vulnerabilities of communities, livelihood resources, natural and physical assets. The NAP will define the medium- to long-term adaptation needs and actions based on the VRA.

Generally, vulnerabilities and risks are rising in Nepal and are expected to rise even faster in the future. In terms of vulnerability, Karnali and Sudurpaschim provinces are extremely vulnerable. Provinces one and two, Bagmati Province, Gandaki Province, and Lumbini Province, on the other hand, have experienced higher risks of climate change impact. Similarly, COVID-19 increased risk and vulnerability and exacerbated socioeconomic and health crises, such as the annual loss and damage caused by climate-related disasters which will hit hard poor people, women, indigenous peoples, the marginalized, and smallholder households and communities[2].

Nepal's NAP will prioritize short-term adaptation options aimed at improving adaptive capacity and addressing physical, socioeconomic, and structural issues, taking into account the population's sensitivity and the livelihood resources on which they rely. Furthermore, through improved forecasting, risk communication, risk transfer, and other disaster risk reduction activities, an integrated vulnerability risk-based approach to adaptation will be focused on reducing the impact of climate-induced extreme events and hazards.

1.4. Process for the LTS preparation

The Ministry of Forests and Environment (MOFE) developed the LTS through a participatory and consultative process with assistance from United Nations Development Programme (UNDP), the NDC Partnership, and the Policy and Institutions Facility (PIF). A technical committee was formed to provide oversight and technical guidance to the LTS process. The LTS was created in collaboration with several governments, international and national organizations, and government line agencies. A series of consultations were held at the national and provincial levels. It was also based on a review of the best available data, as well as a scenario analysis of the existing sector emission datasets, and national and sectoral plans and policies to determine when to achieve net-zero emissions per the IPCC 2006 guidelines for the GHG inventory. A group of experts reviewed the overarching and sectoral policies, strategies and programmes, and the data collection and analysis processes. These assessments were substantiated at the national and provincial levels through in-person and online consultations with line ministries and experts. **Figure 1** shows the overall LTS preparation and approval process.

Nepal’s LTS was developed using scenario-based planning. It is a technique for envisioning and planning potential future states based on a variety of scenarios (Schoemaker, 1995). There are numerous tools and software available for scenario analysis and for developing an

[2] MoFE. 2021. Vulnerability and Risk Assessment and Identification of Adaptation options: summary for policy makers. Ministry of Forests and Environment.

analysis modeling framework. Most of them, however, serve a specific purpose and have limitations – most are either tied to the energy or non-energy sectors. The low emission analysis platform (LEAP) modeling tool enables the integration of both energy and non-energy emissions into a single model. It includes a provision for incorporating the emission of GHGs and other environmental pollutants' emission factors per the IPCC guideline for national GHG inventory estimation.

Figure 1: LTS preparation and approval process

The LEAP model developed for this study categorizes the Energy and Non-Energy sectors (agriculture, LULUCF, waste, and IPPU) with macroeconomic and demographic indicators. In addition, the system draws on technological and resource databases, which are used to build a base model and then develop future scenarios. The study covers the period 2019 to 2050. The energy and non-energy sectors are subdivided into sub-sectors, which are further subdivided based on sectoral activities. Three different sets of possible future energy demands were considered when developing the scenarios, each of which corresponds to a different level of future economic growth.

The energy sector includes emissions from five economic sectors namely residential, industrial, commercial transport, and agriculture. In the reference scenario, the major assumption is that the future trend will follow the current emissions trend. In this scenario, a GDP growth rate of 7% is assumed and there are no technological interventions thus the share of each demand technology remains the same in the future years.

The non-energy sector includes agriculture, LULUCF, waste, and IPPU sectors. In the agriculture and waste sectors, non-CO2 greenhouse gases (i.e., methane and nitrous oxides) are the major sources of emissions. In the agriculture sector, mitigation measures can be categorized into five emission sub-sectors: enteric fermentation, manure management, rice cultivation, biomass (agri-residue) burning, and soil management. The sources of emissions in the waste sector are categorized into solid waste disposal, waste incineration and open burning, and wastewater treatment and discharge. In the IPPU sector, carbon dioxide is the major source of emissions which is attributed to the calcination process in the cement industry. The emissions in LULUCF is assumed to follow the historical trend up to 2050. The LULUCF sector would remain as a net emitter in the reference scenario. The reference scenario assumes that there is no technological intervention in the non-energy sub-sectors up to 2050.

Scenarios with low (4.5%), medium (7%), and high (10.3%) economic growth rates were evaluated. The reference scenario was analyzed at the medium economic growth rate. Furthermore, two mitigation scenarios were also investigated at the medium economic growth rate:

- With the Existing Measures (WEM) scenario is estimated using the same methodology as the reference scenario, but with a focus on the intervention measures specified in the plans and policies implemented and adopted up to 2020. The year 2019 serves as the reference year in this scenario. It assumes the GDP growth rate to be the same as that of the reference scenario. The mitigation measures in the WEM sector were assumed for the implementation of low carbon technologies that were taken into consideration of the NDC 2020, the NPC's roadmap for achieving the SDGs by 2030, and other government's existing plans and policies. Mitigations in the energy sector included electrification in major end-uses in all economic sectors such as efficiency improvement and alternative clean fuel intervention in the industrial process heat, substituting traditional brick kilns with 100% Zigzag brick kilns and biomass fuel mix in the brick industry, fuel switching to modern fuels-electricity, LPG, and renewable energy technologies like solar, and biogas, and modal shift to mass electric mobility in the transport sector. In the agriculture and waste sectors, the strategic action includes measures that reduce both CO_2 and non-CO_2 greenhouse gases. The mitigation measures considered in the agriculture sector include biogas digester in manure management, improved water management in rice cultivation, and low- or no-tillage practices in soil management. In the waste sector, the mitigation options include implementation of methane recovery, anaerobic digester, and waste incinerator, however, the WEM scenario assumes that the implementation level is low. In LULUCF, mitigation measures include reduction in forest degradation and deforestation along with increased plantation and sustainable management of forests. There are no interventions in the IPPU sector in the WEM scenario.

- With the Additional Measures (WAM) scenario, on the other hand, includes the impact of additional mitigation actions that are feasible for the country. These additional mitigation actions are based on an analysis of the country's current GHG emissions profile. this scenario assumes the GDP growth rate is the same as that of the reference scenario. The WAM scenario assumed the implementation of all the proven technologies to the maximum technical feasibility to achieve net-zero CO_2 emissions before or by 2050. Mitigation measures assumed for the energy sector in this scenario included electrification in major end-uses in all the economic sectors. In the industrial sector, mitigation measures assumed were electrification in motive power, boilers, and process heat, and switching to alternative fuel mix and hydrogen technology in the cement industry, and adoption of electric tunnel kilns in the brick industry. To reduce CO_2 emissions in the transport sector, the mitigation measures assumed were the introduction of fuel cells for the passenger as well as freight vehicles, and the use of electric vehicles, synthetic fuel mix in aviation and modal shift to mass electric transportation. In the non-energy agriculture sector, over 20 mitigation measures have been considered, and the mitigation technologies are based on the most recent findings as of 2021 and the implementation potential is assumed to be the maximum technically feasible. Similarly, in the waste sectors, the mitigation measures are implemented at full technical feasibility by 2050. In IPPU sector, carbon capture utilization and storage is considered as the mitigation measure to reduce CO_2 emission in the cement industry. The mitigation measures in LULUCF are similar to the WEM scenario but the level of implementation is more stringent. It is assumed that agri-residue burning on fields would be completely stopped by 2050.

GHG emissions in the WEM and the WAM have been analyzed and compared at the sectoral and the national levels to the reference scenario. Furthermore, carbon neutrality in terms of carbon dioxide only has been assessed until 2050.

Chapter Two: Nepal's Long-term Strategy for Net-zero Emissions

2.1. Vision

"Nepal aspires to minimize emissions and sustainably achieve net-zero emissions by the year 2045."

Key elements of the 2045 Vision

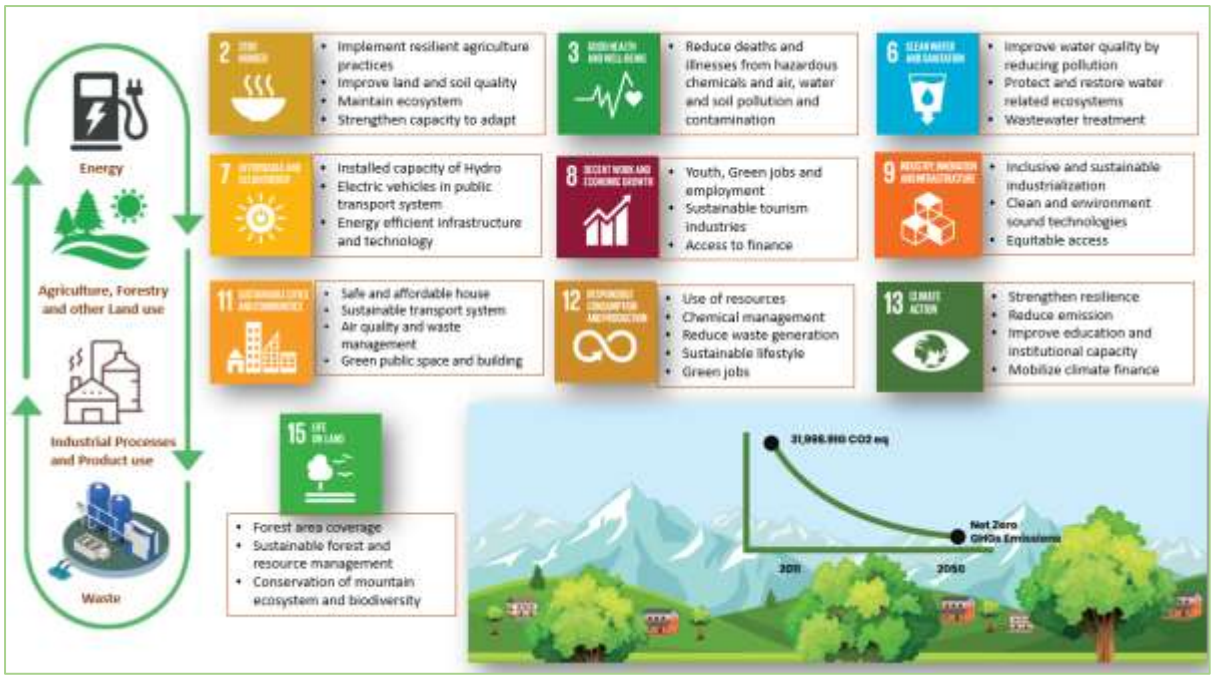
The LTS envisions bold policymaking, social transformation, and technological innovations that will lead to a carbon-neutral, inclusive, and climate-resilient path. The following are the key elements of the LTS:

- Increase the use of clean/renewable power in all sectors, including fuel switching to clean and modern energy in all economic sectors.
- Improve energy efficiency and maximize benefits by utilizing clean energy efficiently in the residential, industrial, and transportation sectors.
- Adopt clean, secure, and connected mobility. This includes decarbonizing the transportation sector through the use of alternative modes of transportation, shifting to electric mass transportation, and increasing the use of clean fuels.
- Increase carbon sinks by managing forests and natural resources in a sustainable manner.
- Encourage sustainable agriculture and land use management to maximize co-benefits.
- Expand the circular economy to improve industrial sustainability, promote industrial sector modernization through installations, and invest in new carbon-neutral and circular-economy compatible technologies and systems.
- Deploy carbon removal technologies in all economic sectors.
- Maximise the benefits of the mitigation of clean energy trade where appropriate mechanisms for recognition are in place
- Enhance international cooperation and support (technical and financial) for climate actions (Mitigation and Adaptation)

2.2. Sustainable development and other considerations

The ambition of Nepal to achieve net-zero emissions by 2045 has clear links to the achievement of the Sustainable Development Goals (SDGs) by 2030 and beyond. Nepal has charted its economic, social, and environmental development course by endorsing the use of 169 targets and 479 indicators to achieve its SDGs by 2030. Climate action is a central cross-cutting policy goal in achieving many of the goals outlined in Nepal's SDG roadmap. The SDGs include both direct and indirect targets and indicators aimed at achieving low-carbon, climate-resilient development in Nepal. Climate action has been fully integrated into the SDGs as a key means of achieving its sectoral goals of sustainable development. **Figure 2** depicts the key theme of Nepal's long-term low GHG emission development strategy with ten of the country's SDG goals and key climate objectives.

Figure 2: Sustainable development considerations in Nepal's LTS



At its core, Nepal's LTS and SDGs promote win-win actions for climate and socioeconomic development, providing Nepal with a critical opportunity to transition to climate-smart development and meet the PA goals and SDGs. Nepal is committed to implementing inclusive and transparent policies to transition its economy to carbon-neutral, climate-resilient, and sustainable development. By addressing climate action and SDGs in integrated ways, the LTS provides a clear vision with co-benefits for achieving socio-economic prosperity and the kind of future Nepal desires. Based on the most recent scientific, technological, and societal developments, Nepal's current and future NDCs will provide a clear pathway for reflection and adjustment to achieve the country's climate and sustainable development goals and provide opportunities for creating jobs for and increasing the income and standard-of-living of the poor people in Nepal.

2.3. Mitigation elements

2.3.1. Current inventory of GHG emissions in Nepal

The Nepal-LEAP modeling framework was used to determine the current status of GHG emissions. The model's starting year was set to 2010, but because 2019 has already passed, the year 2019 was chosen as the base year for developing the GHG inventory. The demographic and economic data, as well as data on various energy and non-energy activities, were obtained from a statistical database available from government documents.

Table 1 shows the emissions of various GHGs from different sectors in 2019. The carbon dioxide from biomass is also included in the table because, in the case of a country like Nepal where biomass is used at an unsustainable rate, the emissions from biomass combustion may not represent renewable energy resources sectors.

Table 1: Emissions in 2019 (in million Metric tons carbon dioxide equivalent, $mMtCO_2e$

Sectors	Methane	Nitrous Oxide	Carbon dioxide	CO_2-equivalent (100-year GWP) [3]
	in $mMtCO_2e$			
Energy Sectors				
Residential	0.41	3.57	2.09	6.07
Transport	0.40	0.01	4.73	5.15
Industrial	0.02	0.02	4.45	4.49
Commercial	0.01	0.13	0.54	0.69
Agriculture	0.00	0.00	0.78	0.78
Sub-total Energy sector GHG Emissions	**0.85**	**3.74**	**12.59**	**17.18**
Non-Energy Sectors				
Industrial Processes and Product Use (IPPU)			1.87	1.87
Agriculture	1.39	26.3	0.17	27.86
LULUCF (emissions)			21.93	21.93
Waste		4.73	0.00	4.73
Sub-total Non-energy sector GHG Emissions (excluding removals)	**1.39**	**31.03**	**23.97**	**56.39**
Total (energy and non-energy) GHG emissions (excluding removals)			**36.56**	**73.57**
LULUCF (removals)			**-13.50**	**-13.50**
Net emissions from LULUCF			**8.43**	**8.43**
Total GHG emissions (excluding LULUCF)	**2.24**	**30.04**	**36.56**	**68.84**
Net GHG emissions	**2.24**	**34.77**	**23.07**	**60.07**

A scenario analysis was performed to investigate potential intervention strategies over the years until 2050. This analysis provides information on the implications of policies

[3] CO_2 equivalent based on 100-year global warming potential (GWP). The GWP for Carbon Dioxide, Methane and Nitrous Oxide are adopted from Fifth Assessment Report (AR5)

implemented in the energy and non-energy sectors, as well as their impacts on net carbon emissions reduction. It should be noted that the analysis excludes livestock emissions because livestock husbandry in the country is based on subsistence agricultural activity and has not been commercialized on a large scale.

2.2.1. Reference scenarios

Figure 3 shows CO2 emissions from the energy and non-energy sectors over the period 2019-2050. Total CO2 emissions in 2019 were 23 mMtCO2. This figure is expected to rise to 34 mMtCO2 in 2030 and 79 mMtCO2 in 2050. In 2019, non-energy-related emissions accounted for 46 per cent of net CO2 emissions, while the energy sector accounted for 54 per cent.

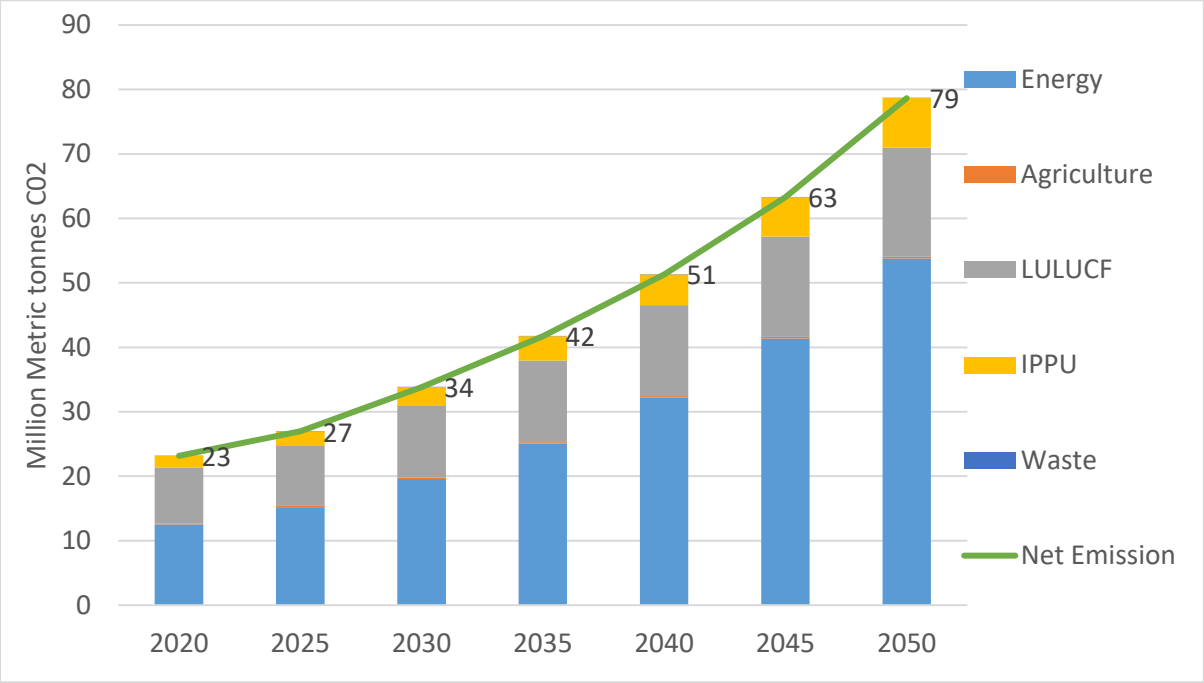


Figure 3: Carbon dioxide emissions in the reference scenario

Non-energy-related emissions would gradually decline to 32 per cent of total emissions by 2050. The CO2 emissions from LULUCF were estimated to be 8 mMtCO2 in 2019, rising to 17 mMtCO2 by 2050.

2.2.2. Mitigation scenarios

Nepal's pathway for Net Zero Emission, two alternative GHG mitigation scenarios is assessed using With Existing Measures (WEM) and With Additional Measures (WAM) have assumed to compare with the reference scenarios. The assumed scenarios include;

WEM: The scenario with the existing measures is estimated using the same methodology as the reference scenario, but taking into account the target of the intervention measures mentioned in the plans and policies implemented and adopted up to 2020, as well as potential adoption with a milestone. The year 2019 serves as the reference year for this scenario.

WAM: The impact of additional mitigation actions that are feasible for the country is estimated using the same methodology as the reference scenario, taking into account the intervention measures mentioned in the plans and policies implemented and adopted up to 2020, as well as the impact of additional mitigation actions that are feasible for the country. The working team identified additional mitigation actions based on an analysis of the country's current GHG emission profile, assumptions about potential technological advancement, and investments.

a. With Existing Measures

Net CO2 emissions will be reduced by 30 mMtCO2 in 2030 and 50 mMtCO2 in 2050 under the WEM scenario (**Figures 4 and 5**). In this scenario, the energy sector will be one of the most important contributors to emissions reductions, while LULUCF will contribute significantly to carbon removal in the earlier period. However, the sink potential of LULUCF will decrease overtime per the assumptions used in this scenario. As a result, after 2030, net carbon emissions will rise at an annual rate of 11%. Under the low intervention carbon reduction measures (described in Section 2.4), it is clear that net-zero emission targets will be impossible to achieve without additional and conditional efforts in carbon removal and sequestration.

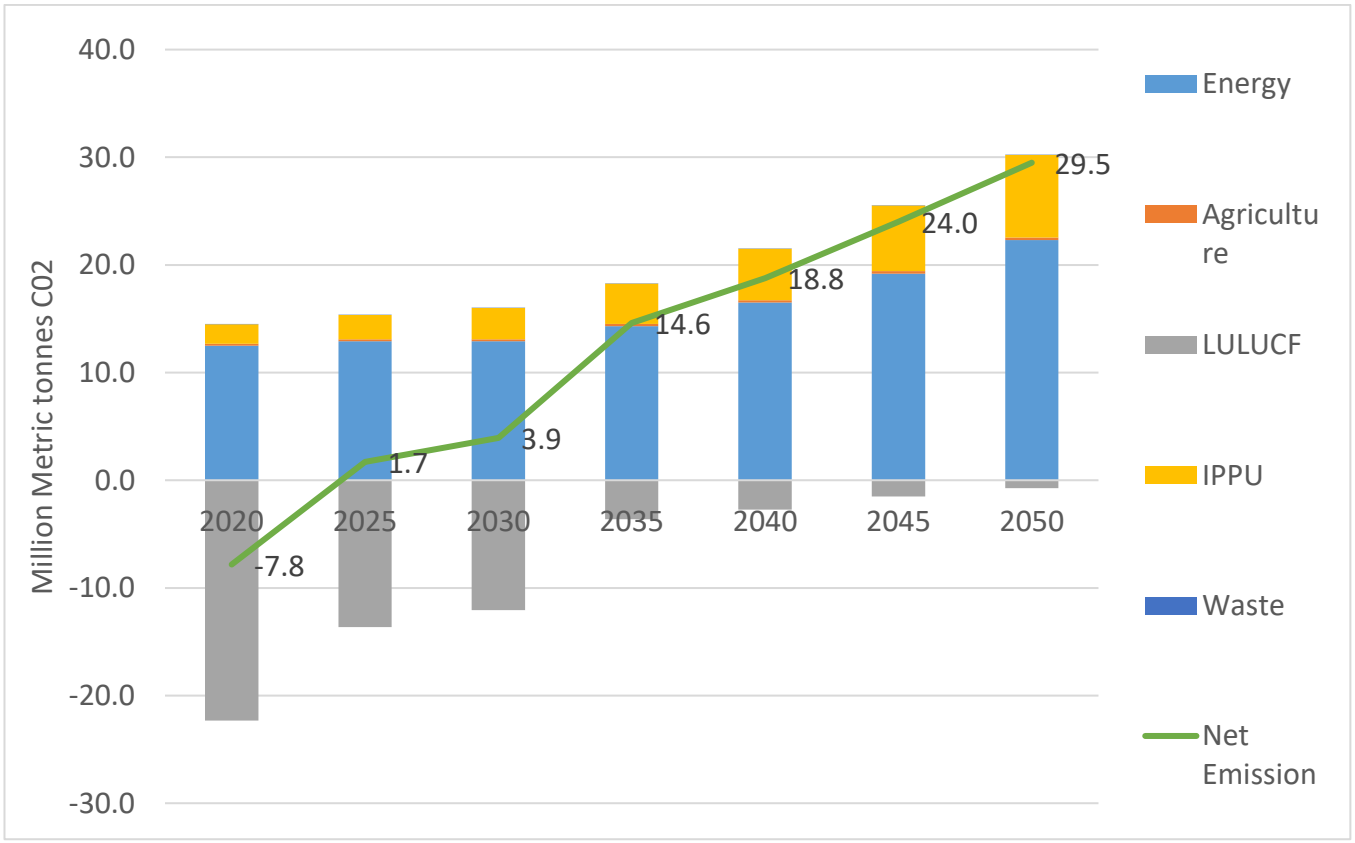


Figure 4: Carbon dioxide emissions in WEM scenario

b) With Additional Measures

The WAM scenario includes very ambitious and conditional targets, which are detailed in Section 2.4 below. This scenario includes new interventions such as fuel cells and biofuels in transportation, green hydrogen for thermal purposes in industry, and carbon capture, utilization, and storage (CCUS). Highly determined interventions in the energy sector, combined with ongoing and additional carbon removal interventions, can pave the way to net zero emissions by 2045, with carbon sequestration potential reaching 5.7 mMtCO2 in 2050. (**Figure 5**). By 2050, emissions from the energy sector will be significantly reduced to a nominal level of less than 2 mMtCO2. LULUCF, on the other hand, will act as a carbon sink, contributing to net negative carbon emissions by 2050.

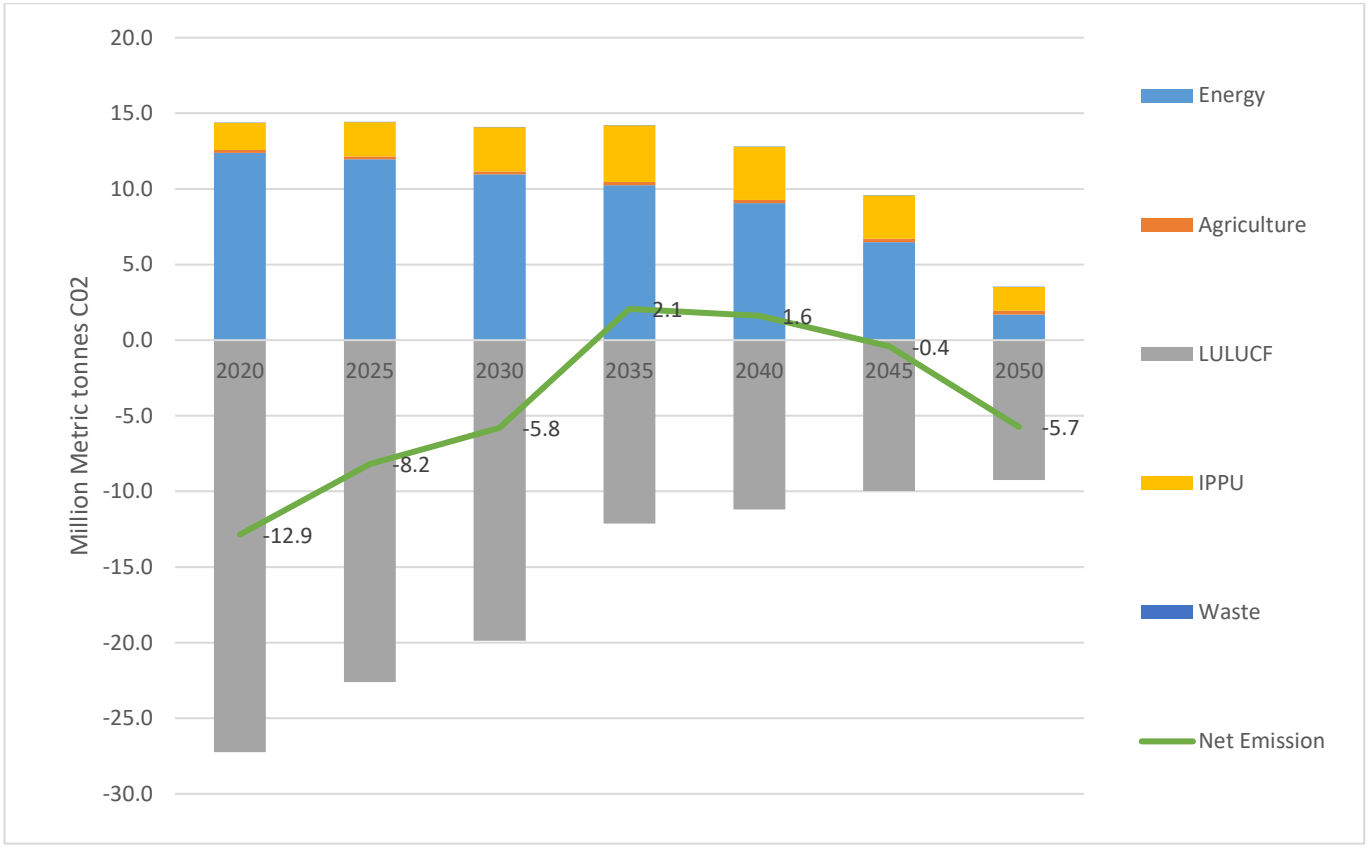


Figure 5: Carbon dioxide emissions in WAM scenario

Due to the limited capacity of current technologies, there are still emissions from energy and IPPU. However, with future technological advancements, this can be avoided and reduced.

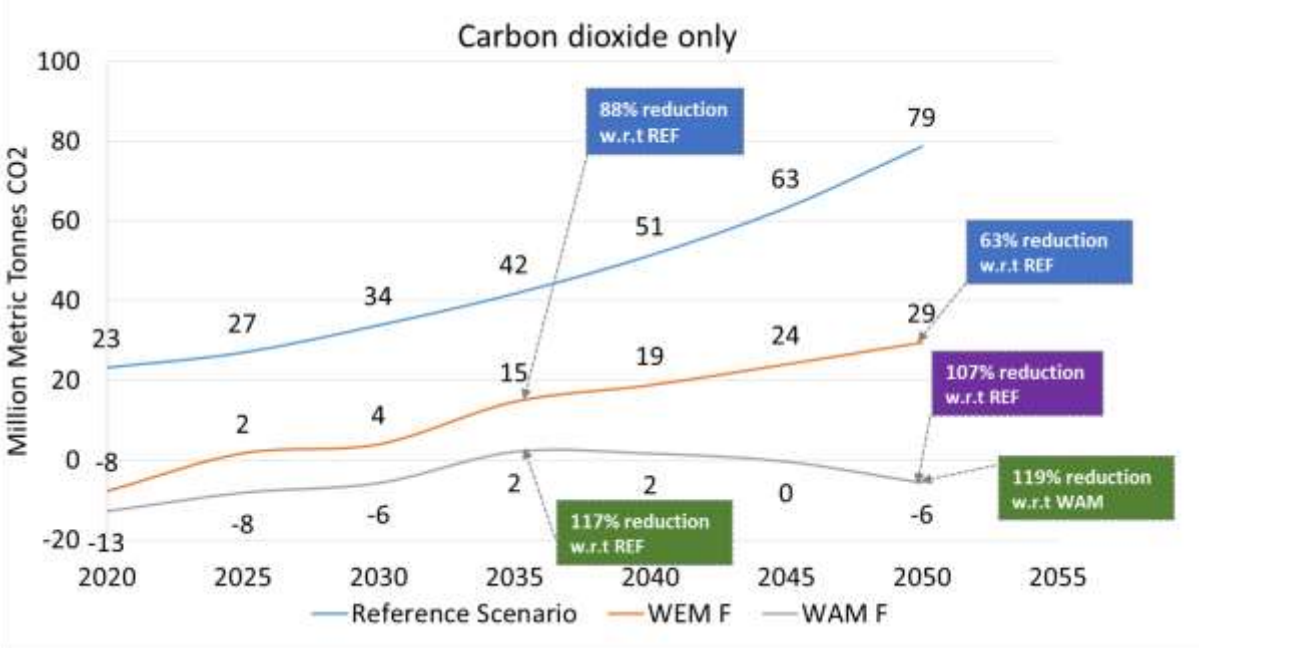
2.2.3. Comparison of scenarios

Figure 6 clearly shows that the country's carbon emissions and reduction potential are very high. With current emissions largely mitigated by carbon capture in the forestry sector and future emissions reduce by aggressive development of clean energy resources. Implementation of strategic measures are capable of reducing emissions to zero to the reference scenario and with ambitious and conditional targets, make net carbon emissions negative, representing net-zero, before or by 2045.

The comparative graphs for emissions for all three scenarios show that Nepal has a high potential for reducing carbon emissions at the national level. With advanced technological and policy interventions, as well as conditional targets, emissions can be reduced while also increasing total carbon sequestration. The WAM scenario indicates that Nepal's net CO_2

emissions will be lower than ‘zero’ in the period 2020 to 2030, then hovering around ‘zero’ level throughout 2035 to 2045, and the sequestration increases from 2045 onwards reaching -5.7 mMT in 2050. These measures can achieve net carbon neutrality immediately and then sustainably by 2045, with increasing levels of carbon capture possible. This carbon sink can help with regional carbon reductions.

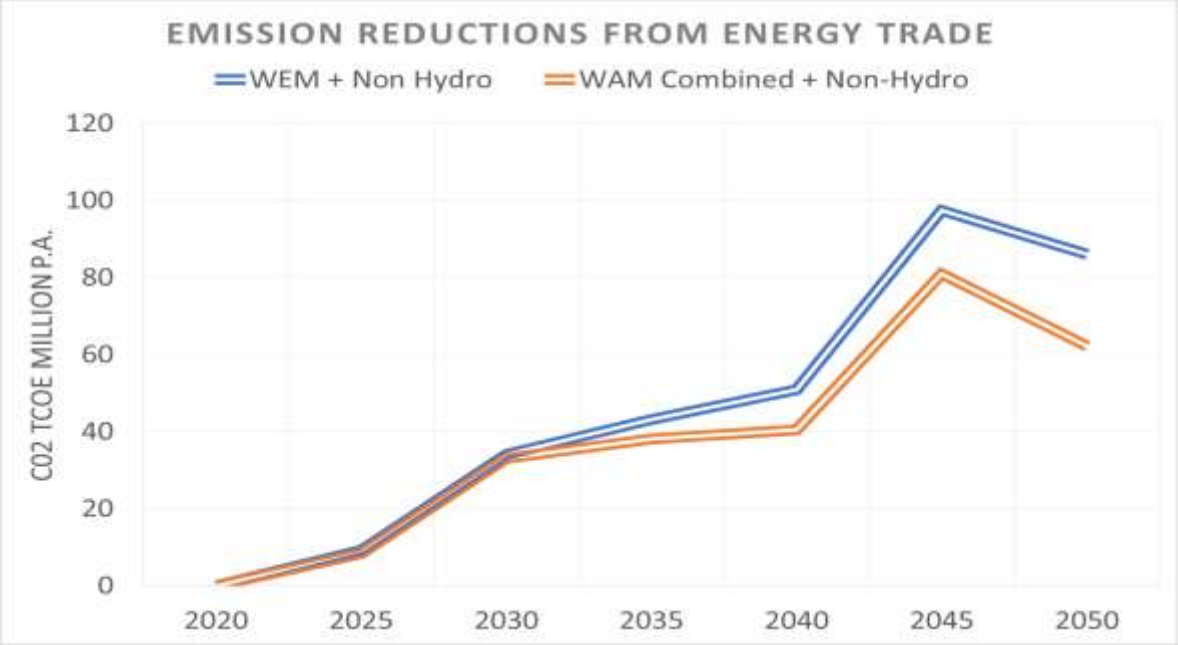
Figure 6: Carbon dioxide emissions in REF, WEM, and WAM scenarios



2.2.4. Implications of Nepal’s Clean Energy Trade Potential on Global Emissions

In addition to its domestic emissions reduction, potential Nepal has significant clean energy resources that can be exported to offset emissions in neighboring countries. The graph below, based on preliminary analysis shows the potential for ‘carbon offsetting’ by developing Hydropower generation capacity of 37 GW - 45 GW by 2050 and accompanying 7 - 9 GW of solar generation capacity. These estimates include meeting rising domestic demand for clean electricity in the national WEM and WAM scenarios and decreasing emissions factors in neighboring countries.

Figure 7: Emission reduction from energy trade



Clean energy trade potential is not accounted for in Nepal's national LTS due to a lack of clarity under the UNFCCC regime. They have however been included here just to illustrate their significance and their potential contribution to Global Emissions Reductions. This can serve discussion agenda to explore flexible mechanisms of enhancing ambitions through regional collaboration.

Figure 8: Impact of avoided emissions from energy trade on Nepal's carbon budget

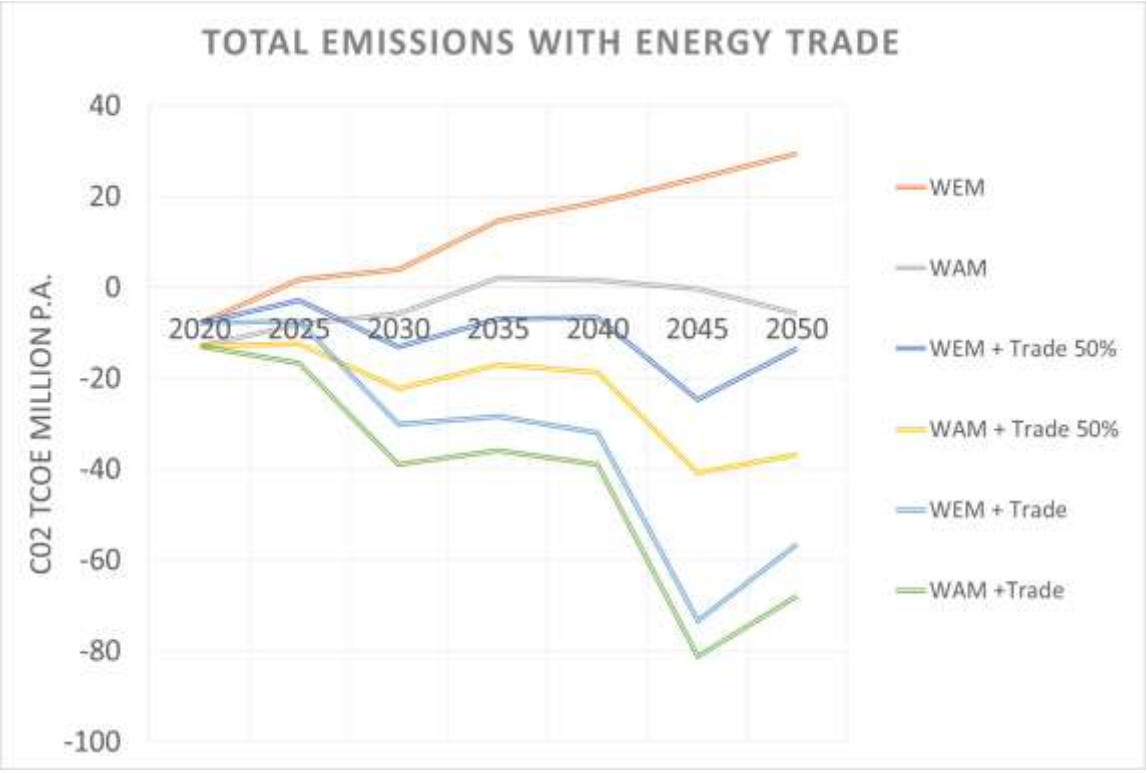


Figure 8 above shows the relative significance of clean energy trade (the WEM/WAM+ trade scenarios) in reducing emissions relative to the purely domestic WEM and WAM scenarios. This implies that if recognized Nepal would be substantially carbon-negative far earlier and to a far greater extent.

This remains true under conservative assumptions. For example, even if only 50% of the emissions reductions are achieved or 'emissions reduction sharing' agreed with recipients (WEM/WAM + Trade 50%) power trade would allow Nepal's emissions to offset significantly become negative by 2030 in both WEM and WAM scenarios even if conservative assumptions on the speed of implementation are adopted. This analysis has therefore been included to ensure recognition of the importance of this issue for Nepal's emissions scenarios and emissions in the region. In particular, it highlights the need for the Article 6 agreement on carbon accounting to take into account the actions of countries like Nepal, who can play a significant role in reducing global emissions, if the right incentives and investment support are put in place.

2.3. Adaptation elements

Mitigation interventions in the energy, agriculture, land use, and forestry sectors will result in adaptation co-benefits that are critical for building resilience at the community, local, provincial, and national levels. Achieving energy security, sustainable forest management, and climate-smart agriculture technologies not only aid mitigation but also develop adaptive capacity and strengthen the livelihood systems of poor people and vulnerable households.

In terms of adaptation and resilience building, Nepal has clearly articulated the country's priority for vulnerable households and livelihood resources. The government has set up a goal of becoming a climate-resilient nation, and it has incorporated the green, resilient, and inclusive development (GRID) agenda into its development policies and plans.

Adaptation is a priority of the country. The government is planning to approve NAP, which will include the government's priorities, implementation plans, and support requirements for medium-term (2030) and long-term (2050) scenarios, plans, and actions. The NAP will outline Nepal's contribution and the means in implementing the contribution to meeting the adaptation goals of the Paris Agreement.

There are limits to adaptation. The adaptation policy and plan alone will not be able to reduce the risk and vulnerability of climate change, particularly the massive loss and damage that can occur as a result of unprecedented events. GON has already prepared a National framework on Loss and Damage (L&D). This framework defined L&D in the context of the country and provided a framework for assessing economic and non-economic L&D caused by climate-related events. The framework is expected to help strengthen governance to address climate risks and vulnerabilities, build the resilience of the water, energy, and agriculture sectors, and reduce disaster risks for people.

2.4. Sectoral strategies

Energy: Nepal uses energy in agriculture, transportation, industry, and commercial and residential sectors. Per the 2019 baseline assessment, residential, transportation, industrial, commercial, and agricultural energy uses contribute to emissions in descending order. Thus, to reduce carbon emissions in the residential sector the use of LPG must be reduced and more electrical appliances, ICS, and biogas must be used. The transportation sector will need to transition to zero-emission transportation for intercity, intracity, and freight travel across public and private modes. The idea is to power the industrial, commercial, and agricultural sectors with renewable energy and hydrogen technologies. Furthermore, in the power

generation sector, all electricity will be generated from renewable sources, primarily hydropower plants, as well as solar PV. Refer to **Table 2** for the strategy in the energy sector.

Table 2: Strategy for the energy sector

Overall sectoral strategies	Sectors	Strategic action	Milestones	
			WEM	WAM
Enhance and maximize Power generation from renewable energy	Power generation	• Development of hydropower plants • Development and integration of variable renewable energy (VRE) into power systems • Scale-up of distributed energy resources (mini-grid, off-grid isolated wind, solar, micro-hydro, and biogas) • Development of policy on regional power sector integration, VRE integration, and grid flexibility	Required power plant capacity in 2050 will be 34 GW – Hydropower 2.1 GW – grid-connected Solar PV power plants, and 1.1 GW of Off-grid and isolated renewable energy power systems	Required power plant capacity in 2050 will be 50 GW – Hydropower 2.1 GW – grid-connected Solar PV power plants, and 1.1 GW of Off-grid and isolated renewable energy power systems
Promote electrification and shift to clean technologies in the residential transportation, industrial and commercial sectors: • Enhancement of clean fuel access • Efficiency improvement • Modal shift and e-mobility in transport • Adoption of New technology in decarbonization	Residential	• Electrification in all end-use services in urban areas • Promotion of clean cooking technologies with high efficiency and low emissions in rural areas • Electrification in cooking, space heating, water heating, and lighting in rural areas	0.3 $mMtCO_2e$ emissions reduction in 2030 and 2.1 $mMtCO_2e$ reduction in 2050, i.e. 9 per cent and 47 per cent reduction in 2030 and 2050 respectively from the	1.7 $mMtCO_2e$ emissions reduction in 2030 and 4.45 $mMtCO_2e$ in 2050, i.e. 53 per cent and 100 per cent reduction in 2030 and 2050 respectively compared to the REF scenario

		• Promotion of efficient technologies in all end-use services	REF scenario	
	Industry	• Expansion of efficient and clean production technologies • Electrification in process heat, boilers, and in motive power in all industries • Replacement of traditional brick kilns (FCBTK) with modern improved brick kilns (zigzag kilns, and electric tunnel kilns) • The intervention of CCUS in the cement industry • The intervention of green fuels (electricity, waste, and hydrogen) for thermal processes in the industries • Introduction of electric technology for process heat in heavy industries (metals, cement, and brick)	3 $mMtCO_2e$ emissions reduction in 2030 and 14 $mMtCO_2e$ reduction in 2050, i.e., 43 per cent and 70 per cent reduction in 2030 and 2050 respectively compared to the REF scenario	3.3 $mMtCO_2e$ emission reduction in 2030 and 19.8 $mMtCO_2e$ in 2050, i.e., 47 per cent and 95 per cent reduction in 2030 and 2050 respectively compared to the REF scenario
	Transport	• Promotion of electric mass passenger transport • Switching fuel to clean energy (electricity, fuel cells, synthetic fuels/biofuels in aviation)	1.9 $mMtCO_2e$ reduction in 2030 and 8.2 $mMtCO_2e$ reduction in 2050, i.e., 26 per cent and 41 per cent	2.1 $mMtCO_2e$ emission reduction in 2030 and 19.5 $mMtCO_2e$ in 2050, i.e., 30 per cent and 97 per cent reduction in 2030 and 2050

		• Electrification in freight transport • Installation and expansion of charging stations	reduction in 2030 and 2050 respectively compared to the REF scenario	respectively compared to the REF scenario
	Commercial	Achieve total Electrification in all commercial sector	1.2 $mMtCO_2e$ reduction in 2030, i.e., 100 per cent reduction in 2030 compared to the REF scenario	1.2 $mMtCO_2e$ emissions reduction in 2030, i.e., 100 per cent reduction in 2030 compared to the REF scenario
	Agriculture	• Electrification in farm machinery and water pumping • Promotion of Solar PV pumping	0.3 $mMtCO_2e$ emissions reduction in 2030 and 1.1 $mMtCO_2e$ reduction in 2050, i.e., 29 per cent and 38 per cent reduction in 2030 and 2050 respectively compared to the REF scenario	0.4 $mMtCO_2e$ emission reduction in 2030 and 2.8 $mMtCO_2e$ in 2050, i.e., 33 per cent and 100 per cent reduction in 2030 and 2050 respectively compared to the REF scenario

IPPU: Nepal's emissions from industrial products and processing units are currently low. However, with the growth forecast and the recommended switch to renewable energy, it will be critical for Nepal to adopt energy-efficient technologies such as zig-zag waste related to fuel and raw materials such as limestone for the cement industry. Nepal must also explore the potential for carbon capture and storage.

AFOLU: For the agricultural sector, Nepal must switch to better cultivation practices, a rice intensification system, better manure management, soil organic matter enrichment, soil management practices such as low soil tillage, use of adaptive and resilient varieties, and breeds, expanded adoption of controlled release of stabilized fertilizers, better enteric fermentation processes, and promote agroforestry and other sustainable agriculture systems. Refer to **Table 3** for the strategy on the agriculture sector.

Table 3: Strategy for the agriculture sector

Overall strategies	Strategic actions	WEM milestone	WAM milestone
Promote agriculture fermentation management practices and technologies	• Employ GHG-focused genetic selection and breeding • Promote animal feeds mix optimization • Expand use of animal feed additives • Expand use of feed-grain processing for improved digestibility • Improve animal health monitoring and illness prevention • Improve technologies that increase livestock production efficiencies	GHG emissions 0.3 $mMtCO_2e$ emissions reduction in 2030 and 1.1 $mMtCO_2e$ reduction in 2050, i.e., 29 per cent and 38 per cent reduction in 2030 and 2050 respectively compared to REF CO_2 emissions 0.3 $mMtCO_2e$ emissions reduction in 2030 and 1.1 $mMtCO_2e$ reduction in 2050, i.e., 29 per cent and 38 per cent reduction in 2030 and 2050 respectively compared to REF	GHG emissions 0.4 $mMtCO_2e$ emission reduction in 2010 and 2.8 $mMtCO_2e$ in 2050, i.e., 34 per cent and 100 per cent reduction in 2030 and 2050 respectively compared to REF CO_2 emissions .4 $mMtCO_2e$ emission reduction in 2010 and 2.8 $mMtCO_2e$ in 2050, i.e., 33 per cent and 100 per cent reduction in 2030 and 2050 respectively compared to REF
Improve soil carbon, soil health, and soil fertility under grassland and cropland	• Expand use of anaerobic manure digestion • Make efficient use of livestock nutrients • Apply Nitrification inhibitors on pasture • Promote technologies that increase livestock production efficiencies	34 $kMtCO_2e$ emissions reduction in 2030 and 133 $kMtCO_2e$ reduction in 2050, i.e., 6.2 per cent and 19.5 per cent reduction in 2030 and 2050 respectively compared to REF	0.12 $mMtCO_2e$ emissions reduction in 2030 and 0.5 $mMtCO_2e$ reduction in 2050, i.e., 21.5 per cent and 67.1 per cent reduction in 2030 and 2050 respectively compared to REF
Improve nutrient use and manure management towards sustainable and resilient	• Improve rice paddy water management • Expand adoption of dry direct seeding in rice cultivation • Improved rice straw management	0.6 $mMtCO_2e$ emissions reduction in 2030 and 2.5 $mMtCO_2e$ reduction in 2050 i.e., 15.2 per cent and 47.4 per cent reduction in 2030 and 2050	0.8 $mMtCO_2e$ emissions reduction in 2030 and 3.6 $mMtCO_2e$ reduction in 2050 i.e., 21.6 per cent and 67.3 per cent

	agricultural systems	• Promote optimal rice varietal selection • Improve fertilization of rice	respectively compared to REF	reduction in 2030 and 2050 respectively compared to REF
		• Scale low- and no-tillage practices • Reduce nitrogen over-application • Promote Variable-rate fertilization • Adopt Nitrogen-fixing rotations • Improve fertilization timing • Expand adoption of controlled-release and stabilized fertilizers	0.1 $mMtCO_2e$ emissions reduction in 2030 and 0.6 $mMtCO_2e$ reduction in 2050, i.e., 4.2 per cent and 13.2 per cent reduction in 2030 and 2050 respectively compared to REF	0.7 $mMtCO_2e$ emissions reduction in 2030 and 2.9 $mMtCO_2e$ reduction in 2050, i.e., 20.2 per cent and 63.2 per cent reduction in 2030 and 2050 respectively compared to REF
	Improve livestock management systems, including agro-pastoral production systems and others	• Methane recovery • Increase incineration		1.4 $mMtCO_2e$ emissions reduction in 2030 and 6.4 $mMtCO_2e$ reduction in 2050, i.e., 5.8 per cent and 18.0 per cent reduction in 2030 and 2050 respectively compared to REF

For Forestry and Other and Land Use: Nepal must increase and maintain its forest cover, adopt afforestation efforts and achieve net-zero deforestation, adopt measures to decrease forest fire incidents, scale-up sustainable forest management practices, agroforestry, and private forestry practices, promote energy-efficient technologies, and improve the monitoring and database systems. Refer to **Table 4** for the strategy for the forestry sector.

Table 4: Strategy for the forestry sector

Overall strategies	Strategic actions	Milestone	
		WEM	WAM

Reduction of forest loss (deforestation) and achieve forest area gain by plantation activities	• Reduce forest loss and stop land cover conversion • Increase forest gain through plantation in an open area • Promote private forestry	Loss: Half of Business As Usual (BAU) 25 per cent of plantation and additional to meet 45 per cent target by 2030	By 2030, net zero Forest Degradation Gain: As per WEM Plantation: Contribution of plantations in removal is doubled, i.e., 50 per cent of plantation area assumed to fall under the definition of forest
Reduce forest degradation and promote forest health	• Reduce degradation from fire, illegal/unsustainable timbering, fuelwood extraction • Reduce unsustainable grazing • Promote alternative domestic energy sources for cooking and heating (e-cooking, ICS, biogas, etc.)	Half of BAU, deduct area under sustainable forest management Fire: Half of BAU	By 2030, 90 per cent reduction in deforestation Fire: By 2030, 75 per cent reduction in forest fire due to different projects for forest fire management and control
Enhance/Improve harvested wood products and avoid carbon loss from forest product/wood products	• Promote the use of harvested wood products in housing and other infrastructure development and construction • Promote farm forestry/agroforestry for the production of wood products • Improve harvesting technology for efficient forest production • Promotion of wood technology (composite wood, particle boards, etc.)	Reduce timber import by half of BAU	Self-sufficiency of harvested wood products.
Adopt an integrated system while using forests for physical infrastructure development and have integrated	• Balance development and physical infrastructure development	Complement forest loss and gain targets	Complement forest loss and gain targets

thinking in its conservation and development (15TH Plan)	• Provide compensation for forest land lost in infrastructure development when forest cover change is unavoidable		
Implement sustainable forest management	• Development of sustainable forest management directives/guidelines • Implementation of silviculture systems to enhance growth in forest growing stock • Promote sustainable forest management	By 2030, 50 per cent of *Terai* and Inner-*Terai* forests, and 25 per cent of middle hills and mountain forests (GoN, 2020)	Between 2030 and 2050, 75 per cent of *Terai* and Inner-*Terai* forests, and 75 per cent of middle hills and mountain forests
Enhance forest information, research, and technology development	• Capacity building for information generation on forest statistics and other forestry-related research • Establishment of systematic observation of forest areas from an emission point of view • Strengthening and generation of baseline data.		Generation of annual average landcover change statistics. Other emission-related forest information (i.e., emission/sink factor of various forest types, emission forest fires, etc.)

Waste: Under waste emissions from solid waste disposal, open burning of waste, and waste-water treatment technologies like methane gas recovery, incineration of waste for heat and power generation, and methane generation from anaerobic digester in wastewater treatment must be promoted. Refer to **Table 5** for the strategy for the waste sector

Table 5: Sectoral strategy, strategic action, and a milestone in the waste sector

Overall strategies	Strategic actions	Milestone	
		WEM	WAM
Implementation of Energy recovery from waste	Methane recovery from landfills	0.7 mMtCO2e emissions reduction in 2030 and 2.9 mMtCO2e reduction in 2050, i.e., 11 per cent and 34 per cent reduction in 2030 and 2050 respectively compared to REF	1.6 mMtCO2e emissions reduction in 2030 and 5.7 mMtCO2e reduction in 2050, i.e., 26 per cent and 66 per cent reduction in 2030 and 2050 respectively compared to REF
	Incineration of waste for heat and power generation		
	Methane generation from anaerobic digester in wastewater treatment		

Chapter Three: Means of Implementation

3.1. Legal and institutional measures

Legal framework: The second enhanced NDC and its future revisions provide a legal basis for the GON to plan and pursue its Long-term Strategy to align its efforts to be very low emissions before and carbon neutrality on or before 2045. In addition, sectoral policies should also mainstream climate change to integrate the targets set in the NDC and the aspirations in the Long-term Strategy. Coordinated efforts across the ministries and line agencies, local governments, stakeholders, and rights holders, access to capacity building, technology transfer, and finance will be key to meet targets set under WEM and WAM scenarios.

***Institutional mechanism*:**

- Implement the LTS through federal, provincial, and local governments, in collaboration with other relevant stakeholders including youth, women, indigenous people, private sector as well as international bodies as it covers multidisciplinary areas.
- Coordinate LTS implementation through the Environment Protection and Climate Change Management National Council, Inter-Ministerial Climate Change Coordination Committee (IMCCCC), Thematic and Cross-Cutting Working Groups, and Provincial Climate Change Coordination Committees.
- Partner with the private sector, development partners, bilateral and multilateral agencies, and international and national non-government organizations to implement LTS.

Stakeholder mapping: Government/Non-government organizations, financial institutions, women groups, youth, children, indigenous people, disabled people, LGBTQ, marginalized groups, civil society organizations (CSOs), private sector, media will be major stakeholders of LTS implementation.

GESI and Leave no One behind (LNOB): Include the principles of equity, ensuring equal access to women, children, youth, indigenous people, disabled people; lesbian, gay, bisexual transgender and queer (LGBTQ), and marginalized groups during participation, decision-making, and benefit-sharing from LTS implementation.

3.2. Means of implementation

Capacity building: Based on the draft capacity need assessment for the NDC, capacity will be built for (i) institutional capacity for governance and coordination; (ii) technical capacity, including sectoral expertise; (iii) relational capacity to build partnerships and invest time in processes; and (iv) strategic capacity for systemic policy design and implementation.

Technology transfer: To meet Nepal's aspirations to be carbon neutral by or before 2045, technology transfer will play a primary role. Moreover, easy access to technology transfer and its affordability will be key incentives in the implementation of long-term strategies. Some technologies will be homegrown for the energy and transport sector, agriculture, IPPU, and waster sector while many will need to be imported.

Finance: The cost of achieving unconditional targets outlined in the NDC is estimated to be USD 25 million. This estimate only covers activity-based targets and does not include the cost of policies, measures, and actions. The cost of achieving the adaptation component will be detailed in the upcoming NAP.

To achieve the conditional targets, Nepal anticipates easy access to finance from multilateral climate financing such as the Green Climate Fund, Global Environment Facility, and Adaptation Fund, Least Developed Countries (LDC) Fund, including from bilateral/multilateral agencies and development partners and the private sector. These funds will be utilized to bolster limited national resources and technical capacities for scaling up climate action.

Market mechanism: The carbon market will also play a key role for Nepal to support and implement various GHG mitigation measures across the sectors. Currently given the potential energy generation forecast, cross-border energy trade provides Nepal the opportunity to engage in market mechanisms under Internationally Transferred Mitigation Outcomes (ITMOs) as refereed on Article 6 of the PA. Similarly, engaging in the non-market mechanism under Article 6.8 for potentially the AFOLU sector will also help Nepal meet carbon neutrality by 2045. International public support in a form of a grant will be needed in this regard.

Monitoring, reporting, and verification (MRV): Nepal's LTS 2050 reflects the most recent data and information, analysis, and scenario for possible future to contribute to the global climate actions in achieving PA goal. As a developing country, Nepal will likely experience dynamic changes due to national and global changes as well as the current COVID-19 pandemic. In this regard, Nepal's LTS 2050 will be monitored, reviewed, and updated, as necessary, taking into consideration national circumstances, capacity and capability, and the provision under the Paris Agreement.

A robust MRV plan will ensure transparency, accuracy, and comparability of information with regards to GHG emissions for each of the five-year periods of the NDC leading towards 2050. The MRV plan, and supporting activities, will strengthen both national and sectoral data and methodologies required to determine GHG emissions across the defined sectors. As MRV is implemented, lessons learned should create a positive feedback loop, strengthening data collection processes and enabling greater accuracy in GHG emission calculations in each sector. The MRV plan for the LTS should underpin the national and sectoral GHG data quality and assist in identifying downstream national and sectoral priorities and strengthen policy planning and prioritization towards a low carbon future.

The MRV process should incorporate assessing existing data, data needs and gap assessment, institutional arrangement, data management along with developing standards and procedures, and finally building and improving the MRV system over time (**Figure 9**).

Figure 9: Proposed MRV system for the LTS

To monitor the national long-term strategy, a set of following indicators should be developed during the monitoring stage. These indicators should be specific and elaborated in each specific project.

- Performance indicators are directly comparable to national targets and they illustrate the results of the strategy as a whole.
- Contextual indicators to help put the results into perspective.
- Indicators relating to the implementation of each cross-cutting and sectoral guidelines
- Indicators of the level of integration of the strategy's guidelines into public policies.
- Additional environmental indicators are provided as part of the strategic environmental assessment.

The results indicators will be updated biennially following the publication of the GHG emission inventories. This biennial monitoring makes it possible to progressively assess the progress of the targets.

3.3. Coordination mechanism

For improved communication and coordination, Nepal will develop clear lines of communication between different levels of governance (local, provincial, national, and international) and across different sectors and stakeholders (**Figure 10**). It includes coordination not only among the government bodies but also among different stakeholders including women, indigenous peoples, youth, private sector, international actors, and CSOs.

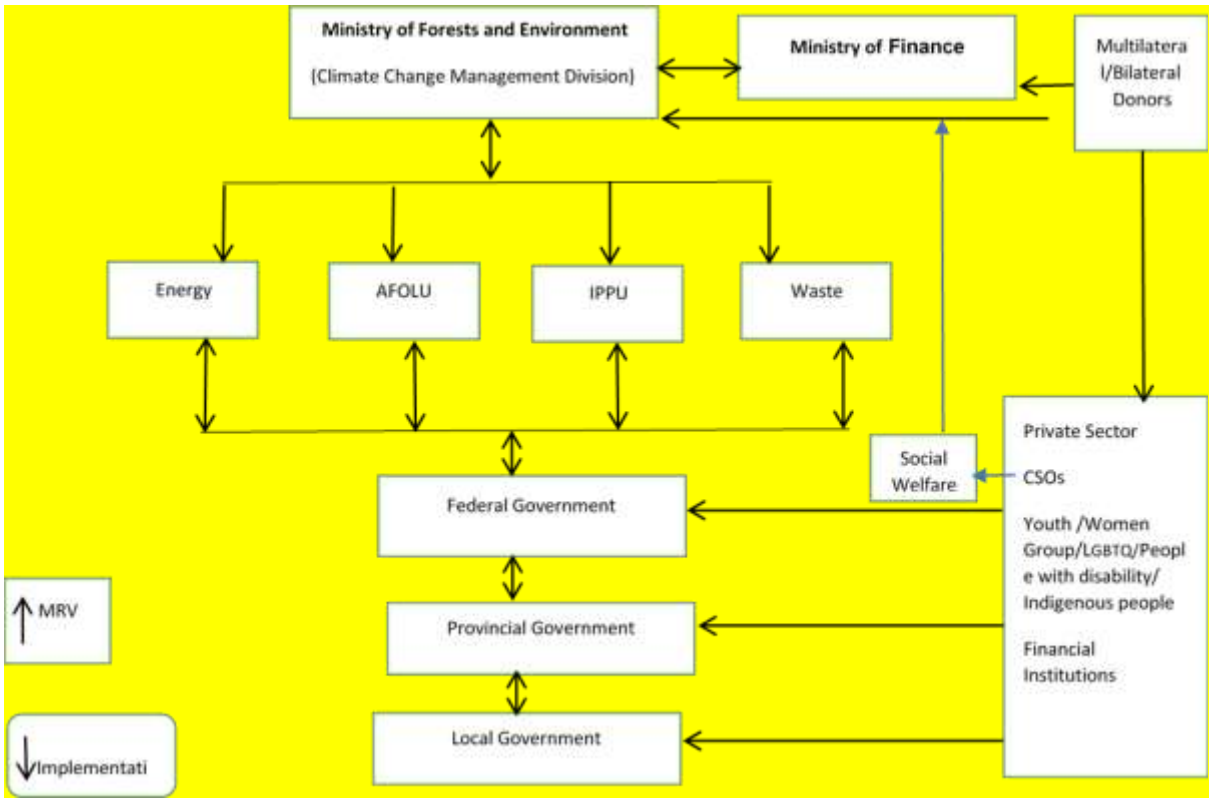


Figure 10: Framework for coordination

Chapter Four: Investment and Finance

According to the cost analysis, significant investment will be required to deliver in GHG mitigation, net abatement costs over the implementation period. Demand-side investment, transformation investment, and non-energy sector investment, such as in forestry, are all included in the investment. It excludes the cost of production of green hydrogen.

4.1. Total yearly costs in 2030, 2040 and 2050

Figure 11 depicts GDP and required costs in 2000 constant US Dollar prices for all scenarios. The investment required under the Reference scenario will be 2.19 percent of the national GDP in 2030, 1.74 percent in 2040, and 6.42 percent in 2050. The investment required under the WEM scenario is 21.39 percent of the national GDP in 2030, 8.03 percent in 2040, and 10.52 percent in 2050. Similarly, the annual investment requirement under the WAM scenario will be 22.05 percent of national GDP in 2030, 14.07 percent in 2040, and 16 percent in 2050.

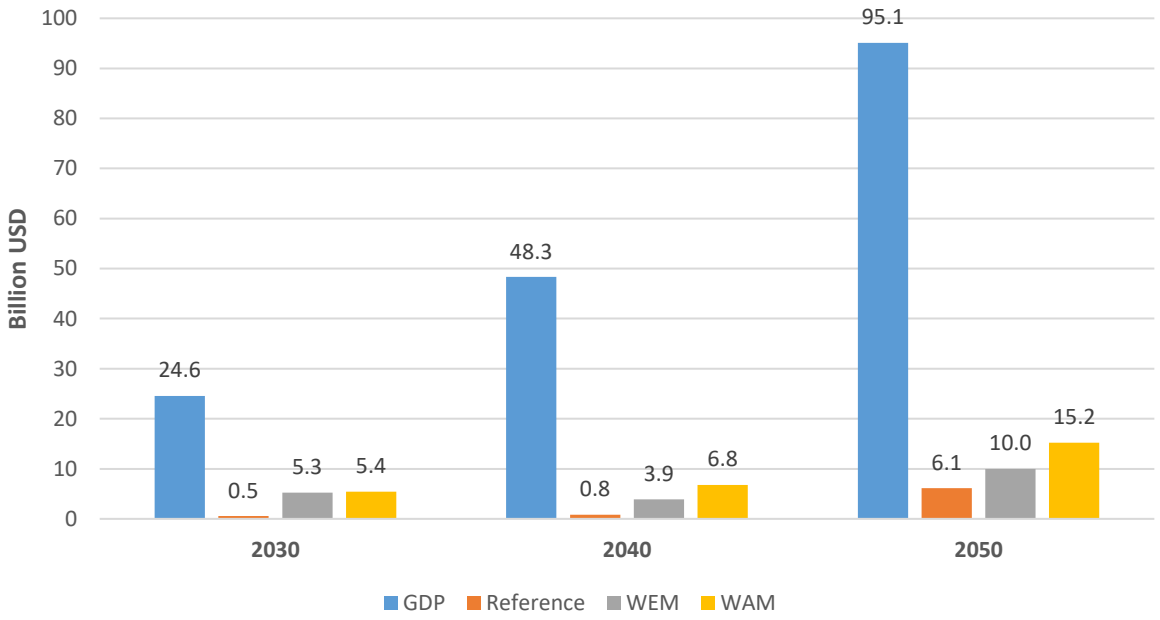


Figure 11: Investment requirements for mitigation measures of Reference, WEM, and WAM scenarios compared to GDP

4.2. Investment costs for the power sector

The installed capacity of power generation would be 4 GW in 2030 and 10.1 GW in 2050 under the reference scenario. In 2030, 14.9 TWh of electricity would be generated, rising to 37.7 TWh in 2050. Under the WEM scenario, electrification measures will result in an additional power generation capacity requirement of 14.3 GW in 2030 and 35.9 GW by 2050, with a 30% reserve margin, mostly through hydropower generation. In 2030, an additional 53 TWh of electricity will be required, rising to 131 TWh by 2050. The required investment in the power sector under the WEM scenario is estimated to be 5.18 billion USD in 2030, 3.78 billion USD in 2040, and 9.85 billion USD in 2050. Similarly, the electrification measures will result in a power generation capacity requirement of 15.2 GW in 2030 and 52 GW by 2050 under the WAM scenario.

In 2030, the electricity demand will be 56.2 TWh, and in 2050, it will be 189.5 TWh. The required investment in the power sector under the WAM scenario is estimated to be 5.34 billion dollars in 2030, 6.69 billion dollars in 2040, and 15.05 billion dollars in 2050. The enormous

capital requirement for electricity generation exceeds the country's capacity. In the South Asia Region, unconditional capital investments for electricity production should be kept within the range of 6% of GDP[4]. The magnitude of investment necessitates comprehensive investment planning in the power sector, as well as the review and formulation of fiscal and sectoral policies, rules, and regulations to attract domestic and international investment. Because hydro and solar power generation is a cleaner source of energy and is frequently used to replace fossil fuels, it is also necessary to investigate the possibility of generating carbon revenue from downstream electrification and power trade to improve the competitiveness of climate change mitigation measures.

Table 5: Power capacity and investment requirement under WEM and WAM

Investment areas	2030		2040		2050	
	WEM	WAM	WEM	WAM	WEM	WAM
Electricity Generation (TWh)	53	56	84	104	131.8	189.5
Power Capacity (GW)	14.3	15.2	22.8	28.5	35.9	52
Investment (billion USD)	5.18	5.34	3.78	6.69	9.85	15.05

Nepal's hydropower development potential is estimated to be around 83,000 MW (Shrestha, 1966), and it can export clean power to its neighbors. Nepal could achieve net zero emissions even sooner than 2045 if it receives carbon offset benefits, provided that Nepal's cross-border power prices are competitive, neighboring countries purchase power from Nepal, and they agree to share the carbon offset benefits with Nepal.

4.3. Cost savings due to decrease in fuel imports

The significant reduction in imported fossil fuels such as diesel, gasoline, kerosene, aviation fuel, coal, and LPG is one of the major co-benefits of implementing GHG mitigation measures identified in the current study. This will eventually help to reduce the country's economic vulnerability, as most of its foreign currency reserves are currently being used to import these fossil fuels, widening the trade deficit.

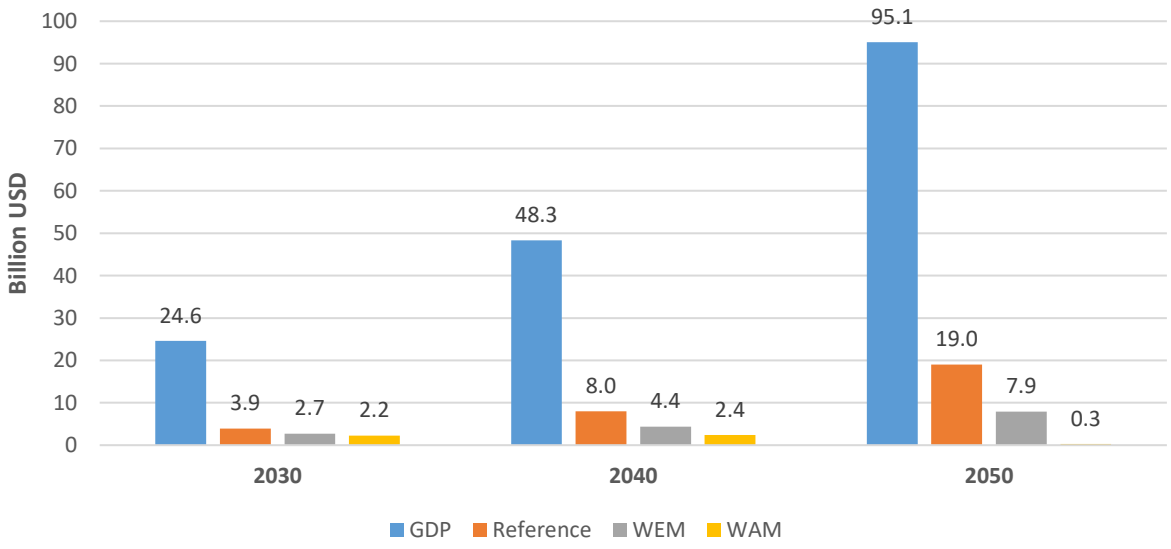


Figure 12: Cost of imported fuels under WEM and WAM scenarios

[4] World Bank policy research working paper (WB, 2015).

Imported fossil fuel costs would be cut by 1.2 billion dollars in 2030, 3.6 billion dollars in 2040, and 11.1 billion dollars in 2050 under the WEM scenario. As shown in Figure 13, this saving amounts to 4.7 percent of the national GDP in 2030, 7.4 percent in 2040, and 11.6 percent in 2050. Similarly, the annual cost savings from imported fossil fuels under the WAM scenario have been estimated at 1.7 billion USD in 2030, 5.6 billion USD in 2040, and 18.7 billion USD in 2050. As shown in Figure 11, this saving amounts to 6.7 percent of the national GDP in 2030, 11.5 percent in 2040, and 19.6 percent in 2050.

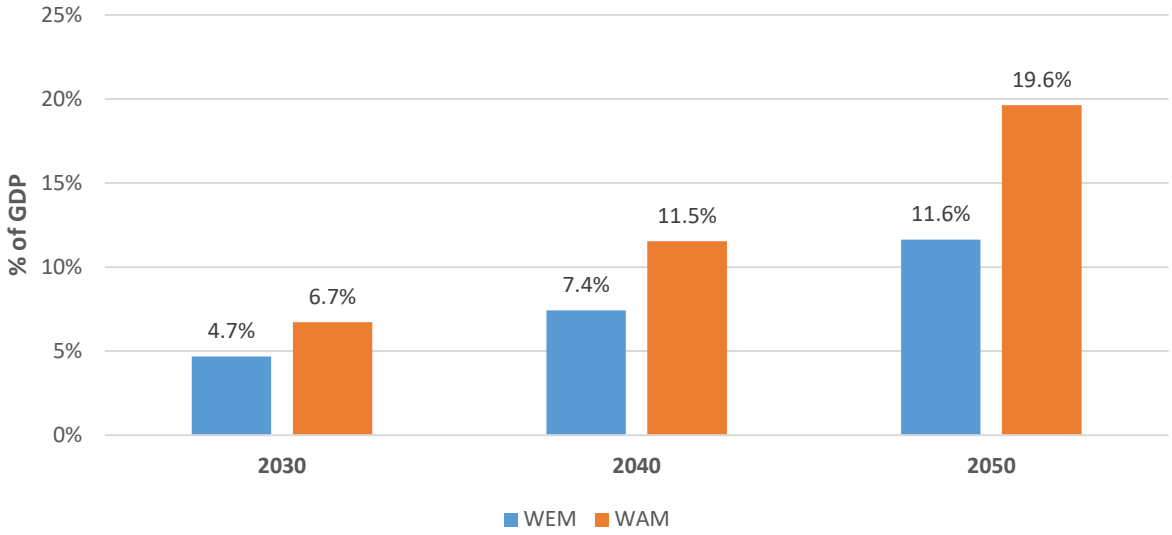


Figure 13: Cost savings from the decrease in fossil fuel imports

4.4. *Cumulative costs over the decades*

According to Figure 14, the total costs of the sectors considered in the Reference scenario are estimated to be 4.2 billion dollars from 2021 to 2030, 7 billion dollars from 2031 to 2040, and 17.5 billion dollars from 2041 to 2050. For the years 2021-2030, 2031-2040, and 2041-2050, this equates to 2.3 percent, 1.9 percent, and 2.4 percent of total GDP, respectively.

In the WEM scenario, the total costs of the sectors considered are estimated to be 42.8 billion USD from 2021 to 2030, 34.4 billion USD from 2031 to 2040, and 56.2 billion USD from 2041 to 2050. For the years 2021-2030, 2031-2040, and 2041-2050, this equates to 23.2 percent, 9.5 percent, and 7.9 percent of total GDP, respectively.

In the WAM scenario, the total costs of the sectors considered are estimated to be 46.4 billion USD from 2021 to 2030, 53.4 billion USD from 2031 to 2040, and 96.3 billion USD from 2041 to 2050. For the years 2021-2030, 2031-2040, and 2041-2050, this equates to 25.1 percent, 14.7 percent, and 13.5 percent of total GDP, respectively.

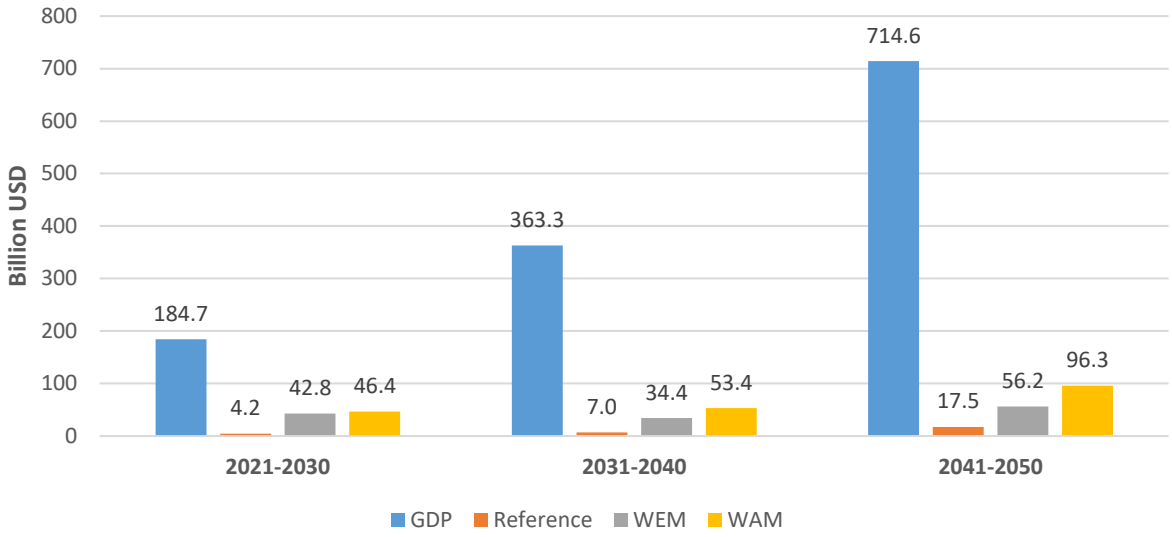


Figure 14: Cumulative costs and comparison to cumulative GDP over the decades

4.5. *Sourcing of Investment and Finance*

Considerable investment and finance are required to achieve WEM and WAM scenarios. For finance deployed from international sources, the strategy will be to pursue bilateral and multilateral funding sources while utilizing a diverse set of international financing instruments such as grants, private sector investments, soft loans, bonds, etc. supported by the necessary public institutions and mechanisms such as fast-track climate change investment boards and foreign currency hedging funds. These will require further strengthening of climate and financial risk analysis tools such as the development of climate impact forecasting tools as well as international credit ratings of public institutions. Further, the development of climate change-based projects could be supported by income from the sale of carbon credits being discussed under Article 6 of the Paris Agreement, depending on the outcome of the negotiations.

Apart from international funding, it is important to have a sustainable funding mechanism through domestic sources. In addition to the public sector, the domestic private sector along with the commercial banking sector will play a major role in mobilizing a large amount of investments. Incentivizing the private sector has multiple benefits from the perspective of the public sector such as sharing of large upfront capital costs required for the financing of climate change projects, smooth operation of projects by private sector companies over the long operation phase of projects, retention of technical knowledge in the market, and sharing of financial liabilities and various risks. Some projects can also be developed under a Public-Private-Partnership (PPP) model to ensure investments and best practices from both the public and private sectors. Thus, the private sector and the commercial banking sector will be engaged as the major stakeholders to achieve net-zero emissions.

Adequate measures will be undertaken to ensure incentives for the adoption of climate-friendly technologies for the end-user, and promotion of these technologies by investors. The custom duties and taxes by the government levied on climate change-related projects and high debt interest rates levied by local commercial banks are major barriers to domestic investment. Thus, adequate measures will be undertaken to verify projects related to climate change and ensure adequate incentives such as a decrease in the duties and taxes, service-based subsidies or government rebates on sales, and public financing of a substantial portion of interest rates from commercial banks. Similarly, deterrents such as taxes and fines on the use of fossil fuels and fossil-fuel-based technologies will be strengthened further, and the income from such deterrents will be invested into climate change projects at the national level. The strategy will be to push the climate change projects towards financial viability through adequate market-based incentives and deterrents to ensure the sustainability of these projects.

These measures to increase domestic investment in the climate change sector will be strengthened through the enactment of necessary Acts and Regulations such that they can be institutionalized over the long run to adequately signal private sector investors and ensure the safeguarding of investments. As climate change projects are multi-disciplinary, adequate measures will be taken to increase awareness and sensitize government institutions at the federal, provincial, and local levels towards the urgent nature of implementing climate change-based projects. The scale of investment required for climate change projects is immediate and large, thus adequate institutional measures will be undertaken to ensure fast-tracking of both domestic and international climate change-based investments, with a supporting framework for categorization, tracking, monitoring, reporting, verification, and evaluation promptly. By following the aforementioned international and domestic financing strategy, Nepal will aim to achieve net-zero emissions resulting in maximum net socio-economic benefits while ensuring financial feasibility and environmental sustainability.

Annex 1: Co2 Emissions data under various scenarios

Scenarios	Million metric tons co2 emissions								
WAM									
		2019	2020	2025	2030	2035	2040	2045	2050
	Energy	12.5	12.4	12.0	11.0	10.2	9.1	6.5	1.7
	Agriculture	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	LULUCF	8.4	-27.2	-22.6	-19.9	-12.1	-11.2	-10.0	-9.2
	IPPU	1.9	1.8	2.3	2.9	3.7	3.5	2.8	1.6
	Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Net Emission	23.0	-12.9	-8.2	-5.8	2.1	1.6	-0.4	-5.7
WEM									
		2019	2020	2025	2030	2035	2040	2045	2050
	Energy	12.4	12.5	12.9	12.9	14.3	16.5	19.2	22.3
	Agriculture	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	LULUCF	8.3	-22.3	-13.6	-12.1	-3.6	-2.7	-1.5	-0.7
	IPPU	1.9	1.8	2.3	2.9	3.7	4.8	6.1	7.7
	Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Net Emission	23	-7.8	1.7	3.9	14.6	18.8	24.0	29.5
REF									
		2019	2020	2025	2030	2035	2040	2045	2050
	Energy	12.5	12.5	15.2	19.6	25.1	32.2	41.4	53.8
	Agriculture	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	LULUCF	8.4	8.7	9.3	11.1	12.7	14.1	15.5	16.9
	IPPU	1.9	1.8	2.3	2.9	3.7	4.8	6.1	7.7
	Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Net Emission	23	23	27	34	42	51	63	79