Government of Nepal
Ministry of Forests and Environment

TECHNOLOGY NEEDS ASSESSMENT FOR CLIMATE CHANGE MITIGATION

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Technology Needs Assessment for Mitigation Technologies

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FOREWORD

Nepal's contribution to global greenhouse gas emissions (GHGs) is negligible. Despite the minor emissions, Nepal aims to achieve net-zero greenhouse gas emissions by 2050 through strategic interventions in the energy, transportation, agriculture, and waste management sectors. To accomplish this, the country has committed to a long-term low-carbon emission pathway that effectively reduces GHG emissions while also improving climate resilience. These ambitions and commitments are well articulated in national policy documents such as the National Climate Change Policy, the Second Nationally Determined Contributions, the Periodic Plan, and Nepal's Sustainable Development Goals and targets.

The substantial financial and technological resource is crucial for achieving the national target of net-zero emission by 2050. It requires support from both international communities and national initiatives. Along with this, identification of the implementable mitigation technologies is vital that will also provide an opportunity for development and scaling up innovative mitigation technologies.

This assessment for climate change mitigation was carried out with the assistance of the GEF and the UNEP DTU partnership. The mitigation technologies for the energy, transportation, and agriculture sectors were chosen due to their greater potential for reducing GHGs while also providing adaptation benefits. A highly consultative process involving sectoral experts, academia, and civil society organizations resulted in the prioritization of technologies. This report is an outcome of a collective effort from various institutions and individuals who provided their invaluable comments, inputs, and suggestions in the preparation of this report. I am grateful to Dr. Biswa Nath Oli, former secretary of MoFE for his strategic guidance in finalizing this report. Similarly, I am thankful to colleagues from Climate Change Management Division (CCMD) who were involved in finalizing this report.

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Despite contributing a negligible amount to global greenhouse gas emissions, Nepal has increased its climate ambition by committing to net-zero emissions by 2050. The ambition for low-carbon development is well articulated in the Government of Nepal's National Climate Change Policy 2019 and its second Nationally Determined Contribution (NDC) 2020 following the Paris Agreement.

I am confident that the Technology Needs Assessment for Climate Change Mitigation, commissioned by the Ministry of Forests and Environment (MoFE) of the Government of Nepal with support from the Global Environment Facility and the United Nations Environment Programme, will provide an opportunity to introduce and disseminate prioritized mitigation technologies in the energy, agriculture, and forestry sectors of the country.

The report's prioritized mitigation technologies are the result of a thorough consultative process with relevant stakeholders and experts at the national level. I am optimistic that the mitigation technologies recommended in this assessment report will help to accelerate climate action and facilitate low-carbon development at all levels of government, including local, provincial, and federal, by reducing emissions from various sectors. At the same time, I believe that implementing these mitigation technologies will improve the country's ability to reduce emissions and contribute to the country's net-zero ambition. I am confident that national and international development partners will step in to support the promotion of prioritized technologies as part of the Nepalese government's efforts to ensure a low-carbon, climate-resilient society.

I'd like to thank the TNA team for conducting this assessment on behalf of the Ministry of Forests and Environment. I gratefully acknowledge the assistance provided by Climate Change Management Division Colleagues Dr. Arun Prakash Bhatta, Mr. Raju Sapkota, Ms. Srijana Shrestha, Ms. Shreejana Bhusal, Ms. Muna Neupane, Mr. Yam Prasad Pokharel, Mr. Ram Prasad Awasthi, Mr. Narayan Raymajhi, Mr. Som Nath Goutam, and Mr. Hari Krishna Laudari.

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ABBREVIATIONS

ADB	Asian Development Bank
AEPC	Alternative Energy Promotion Centre
AFOLU	Agriculture, Forestry and Other Land Use
AIT	Asian Institute of Technology
ATF	Aviation Turbine Fuel
AWD	Alternate Wetting and Drying
BoP	Balance of Payment
BRT	Bus Rapid Transit
CBS	Central Bureau of Statistics
CCMD	Climate Change Management Division
CNG	Compressed Natural Gas
COP	Conference of Parties
CTCN	Climate Technology Centre and Network
DFRS	Department of Forest Research and Survey
DSR	Direct Seeding in Rice Cultivation
DWSS	Department of Water Supply and Sanitation
ENR	Enhanced Natural Regeneration
EPA	Environment Protection Act
EPC	Environment Protection Council
FAR	Fifth Assessment Report
FRA	Forest Resource Assessment
FY	Fiscal Year
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GoN	Government of Nepal
HFC	Hydrofluorocarbon
IA	Implementing Agency
ICIMOD	Integrated Centre for International Mountain Development
ICS	Improved Cooking Stoves
INC	Initial National Communication
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LDC	Least Development Country
LPG	Liquefied Petroleum Gas
LULUCF	Land-use, Land-use Change and Forestry
MCCICC	Multi-stakeholder Climate Change Initiatives Coordination Committee
MCDA	Multi-criteria Decision Analysis
MoE	Ministry of Environment
MoF	Ministry of Finance
MoFE	Ministry of Forests and Environment
MoPE	Ministry of Population and Environment
MoST	Ministry of Science and Technology
MoSTE	Ministry of Science, Technology and Environment
NAPA	National Adaptation Programme of Actions
NARC	Nepal Agriculture Research Council
NCCP	National Climate Change Policy

NDC	Nationally Determined Contributions
NEA	Nepal Electricity Authority
NEEP	Nepal Energy Efficiency Programme
NEPAP	National Environmental Policy and Action Plan
PMU	Project Management Unit
PSP	Poznan Strategic Program
REDD	Reduced Emission from Deforestation and Forest Degradation
SNC	Second National Communication
TFS	Technology Fact Sheets
TNA	Technology Needs Assessment
TNC	Third National Communication
UMMB	Urea Molasses Mineral Block
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank
WECS	Water and Energy Commission Secretariat

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Executive Summary

Technology Needs Assessment (TNA) dates back to 2001 at the Marrakech Conference of Parties where the technology transfer framework was established and formalized under the United Nations Framework Convention on Climate Change (UNFCCC) process. The main objective of TNA is to identify, evaluate and prioritize technology means for mitigation and prepare action plan that will enable to achieve development equity and environmental sustainability, and to follow climate resilient development pathway. Ministry of Forests and Environment (MoFE) is the functional arm of the government setup to regulate country's environment, forests, wildlife, National Parks and wetlands by promulgating different Acts, policies, guidelines, rules, regulations and programmes/projects for these sectors. Under MoFE, Climate Change Management Division (CCMD) is mandated to deal with climate change issues at the international, national and sub-national levels. The "Climate Technology Section" under the CCMD is the focal point for TNA related affairs.

In Nepal, introduction and dissemination of new technologies is crucial in reducing current level of Greenhouse gas (GHG) emissions. Access to appropriate technology and financial resources impedes Nepal's ability to implement mitigation options by limiting the range of possible responses. Mitigation capacity is likely to vary, depending on availability and access to technology at various levels - from local to national and in all sectors. The stakeholder driven TNA was carried out to identify and prioritize climate change mitigating technologies that are in line with the social, economic and environmental development priorities of Nepal and will maximize the climate resilience of the people. Although this report is based on the stakeholder consultation process carried out during 2012/13, it has been updated as per the federalism and recent national policies. Therefore, the technologies identified in the report are still relevant in the present climatic context of Nepal.

The overall process of TNA was set to prepare a detailed and representative description of list of prioritized technologies that can contribute to achieve mitigation goals of the country while identifying the barriers hindering the acquisition, deployment, and diffusion of these technologies. It started with stakeholders' workshops which involved national experts from different governmental and non-governmental agencies. This led to the preparation of portfolio of technologies which included technologies from simple to advance.

These workshops finalized three sectors as the most potential and of highest priority to mitigate the current level of emissions without compromising the foster of economic development of the sectors. The development priorities were based on the literature review of various documents like Initial National Communication, Millennium Development Goals Report for Nepal and other national reports on development, strategies and National Inventory of GHG emissions. The prioritized sectors were energy, agriculture and forestry. Possible mitigation technologies were identified for each sector and preliminary short listing of the technologies was performed to screen the most potential technologies that behold the issues and concerns of the national development priorities and has potential to mitigate GHG emissions. Technology factsheets were prepared for the shortlisted technologies and shared with the stakeholders in Stakeholders' consultation workshop on technology prioritization. Various social, economic and environmental development priorities including the cost of the technology were considered as the criteria to finalize the technology prioritization.

Multi Criteria Decision Analysis approach was used to prioritize the sectors and technologies. The technologies were scored and weighted by the stakeholders during the consultation workshop based on the technology factsheets that were provided. Overall weighted score was the basis to rank the technologies. The technologies were ranked according to their performance and contribution to national development priorities. There were 15 experts involved in each sector for prioritization process. The result was shared among the stakeholders and it was unanimously accepted. Finally, sensitivity analysis of technologies was performed to evaluate the technology prioritization and as a result, following technologies were prioritized:

SN	Sector/Technology	Availability/Scale
Energy		
1.	Electric Cook Stove	Long-term/small-scale
2.	Biogas	Short-term/medium-scale
3.	Bus Rapid Transit	Short-term/medium scale
Agriculture		
4.	Urea Molasses Mineral Block	Short-term/large scale
5.	Alternate Wetting and Drying	Short-term/small scale
Forestry		
6.	Silviculture	Short-term/medium scale
7.	Short Rotation Forestry	Short-term/medium scale

CHAPTER-1: INTRODUCTION

1.1 Background

1.1.1 Global Context

Climate change is one of the major threats the world has ever faced. The process of gradual warming of the earth due to increased concentration of greenhouse gases (GHG) is expected to impart multi-faceted impacts that interfere with the environmental, social and economic systems. Rising concentration of atmospheric CO_2 was observed; however, the global community realized the need of wider consensus to reduce global GHG concentration only in 1989 when the Intergovernmental Panel on Climate Change (IPCC) released its first assessment report with an indication that the global GHG concentrations have increased as a result of human activities. As a result, United Nations Framework Convention on Climate Change (UNFCCC) was negotiated. This global framework treaty was opened for signature in 1992 at Earth Summit and ultimately entered into force in 1994.

Article 2 of the convention set out the objective of the convention and any other legal instruments related to the convention as "*to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.*"

The convention also recognized, owing to their historic emission, the developed countries to lead in process of combating the climate change. Further, the article 4 of the convention emphasized on the principle of "*common but differentiated responsibilities*" among the developed and developing country parties and kept onus on the developed country parties to assist the developing country parties in their act for combating climate change by channelling new funds. While doing so, paragraph 3 article 4 of the convention obliges developed country parties to provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of implementing measures outlined under paragraph 1 of the same article.

Paragraph 1 of the article 4, among others, requires parties to promote and cooperate in the development, application and diffusion including transfer, of technologies, practices and process that control reduce or prevent anthropogenic emission of greenhouse gases;

and promote and cooperate in the full, open and prompt exchange of relevant scientific, technological, technical, socio-economic and legal information related to climate system and climate change, and to the economic and social consequences of various response strategies.

IPCC's fifth assessment report (AR5) confirms "human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems." Similarly, AR5 also concludes that the effective adaptation and mitigation responses will depend on policies and measures across multiple scales: international, regional, national and sub-national. Policies across all scales supporting technology development, diffusion and transfer, as well as finance for responses to climate change, can complement and enhance the effectiveness of policies that directly promote adaptation and mitigation.

Despite nominal contribution to the climate change, Nepal is committed towards regional/international/global climate change treaties, agreements or initiatives. Nepal has signed UNFCCC and ratified the Kyoto Protocol and Paris Agreement. Nepal is a party to other such global/regional initiatives/treaties. As a part of these treaties, Nepal has submitted national communications. Nepal has also prepared and implemented National Adaptation Programme of Actions (NAPA) in 2010. National Climate Change Policy was formulated in 2011 (updated in 2019). In 2016, Nepal submitted its first Nationally Determined Contribution (NDC) and the second NDC was prepared and submitted in December 2020 which aims to achieve carbon neutrality by 2050.

1.1.2 Evolution of the TNA and Underlying Process

History of Technology Needs Assessment (TNA) dates back to 2001 at the Marrakech Conference of Parties where the technology transfer framework was established and formalized under the UNFCCC process. Since its inception in 2001, more than 80 developing countries have undertaken TNAs to assess their technology needs for addressing climate change. In the history of evolution of TNA, two distinct segments of development can be identified; first segment, from 2001 to 2008 when most of the developing country parties were supported to understand their technological needs and priorities for reducing greenhouse gas emissions. And, second segment i.e. post 2008 when the emphasis has been given to implement the identified technologies to a real case projects and programs. The TNA process aspires to identify technological means to address climate change and accelerate national development, build national capacity to support national sustainable development and create technology action plans to achieve implementation and demonstrate technology viability.[1]

[1] https://unfccc.int/ttclear/tna/history.html (visited on 18 Nov 2020)

Realizing the need of technologies to effectively address climate change mitigation and adaptation needs, and also to comply with the convention's obligation towards parties, the TNA process, at the Fourteenth Conference of the Parties (COP-14) to the UNFCCC, the Poznan Strategic Program (PSP) was created in 2007 through which Global Environmental Facility (GEF) provides funding to climate technology development and transfer activities. In 2008 the 14th Conference of Parties renamed PSP as the Poznan Strategic Programme on Technology Transfer. In 2010, the GEF submitted to the COP a plan for the PSP's long-term implementation. This plan contained five elements: support for climate technology centers and a climate technology network; piloting priority technology projects to foster innovation and investments; public-private partnership for technology transfer; TNAs; and GEF as a catalytic supporting institution for technology transfer[2]. The program was established with the aim to scale up investment in technology transfer thus enabling developing countries to address their needs for environmentally sound technologies.

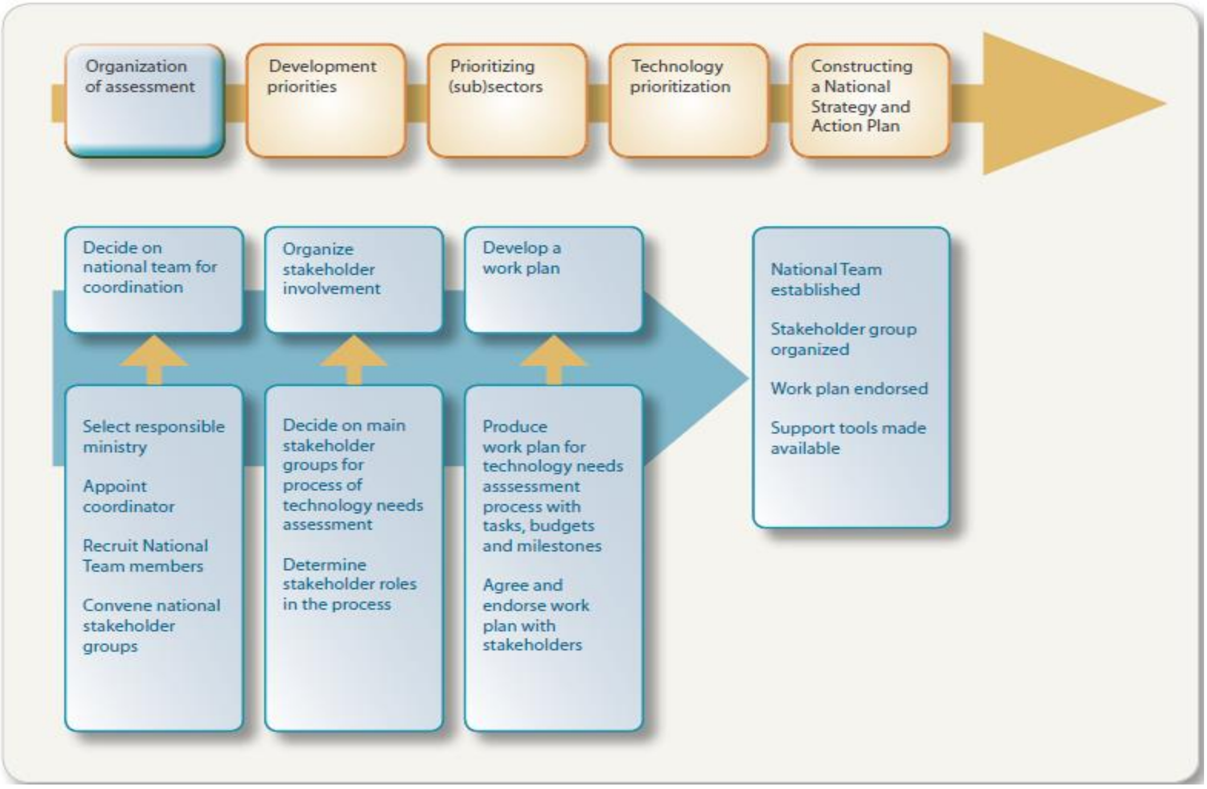

Figure 1: Overview of the Organization of TNA Process[3]

Enhancing technology development, transfer, deployment and dissemination is a key pillar of the international response to climate change. As a result, and to support the implementation of the UNFCCC Paris Agreement, Parties to the UNFCCC are engaged in the elaboration of the technology framework to further promote and facilitate enhanced action on technology development and transfer, where the work on Technology Needs Assessments will play a key role in the implementation of environmentally sound

[2] https://unfccc.int/ttclear/support/poznan-strategic-programme.html
[3] Figure sourced from A handbook for conducting Technology Needs Assessment for Climate Change (UNDP, 2010)

technologies for mitigation and adaptation. With funding from the Global Environment Facility, UN Environment, through UNEP DTU Partnership, supports developing countries to determine their technology priorities for the mitigation of greenhouse gas emissions and adaptation to climate change through the global TNA project. The TNAs were directly referenced in the Paris agreement, requesting that the new technology framework should facilitate:

a) The undertaking and updating of technology needs assessments, as well as the enhanced implementation of their results, particularly technology action plans and project ideas, through the preparation of bankable projects; and
b) The provision of enhanced financial and technical support for the implementation of the results of the technology needs assessments.

1.1.3 Context of the Assignment

The then Ministry of Science, Technology and Environment (MoSTE) with the support from UNEP acting as the Implementing Agency (IA) of the Global Environment Facility (GEF) drafted the Technology Needs Assessment (TNA) as a part of the activities included in the UNFCCC. The main components of this was to identify and analyse technology needs, which can form the basis for a portfolio of climate friendly technologies and projects/programmes to facilitate the transfer of, and access to, climate friendly technologies and know-how in the implementation of Article 4.5 of the UNFCCC.

With regards to the TNA, Nepal was one of the participating countries in the first phase of TNA Global Project (2009-2013). By far, Nepal is yet to submit a formal TNA country report.[4] However, Nepal has an accomplished project listed titled "Developing policy framework and business model to promote sustainable use of biomass briquettes in Nepal" with technical assistance from Climate Technology Centre and Network. The project brief states that Nepal has conducted TNA in 2014 which however is not available in public domain.

The first draft of TNA reports was completed in 2014. In 2015, the country underwent overhaul in the governance system (unitary system to federal system). With the change in governance and ministerial leadership, the TNA process faced stalemate. In the meantime, the MoFE, which inherited the climate change affairs from the then MoSTE, had started its third national communications (TNC) process which is recently published. In order to capture the context of updated information from the TNC and other policy and structural changes related to climate change governance in Nepal, MoFE has updated the draft TNA report for its submission to the UNFCCC. MoFE commissioned a consultant to update the initial draft of the TNA in light of the governance change and updated national

[4] https://unfccc.int/ttclear/tna/reports.html (accessed on 18 Sep 2020)

GHG inventory for Nepal. However, for the outcomes resulting from the stakeholder consultation, the original outcomes were retained with required modification to contextualize the content. The potential mitigation technologies recommended are still relevant and applicable in the current climatic context.

1.2 National Circumstances on Climate Change

1.2.1 Climate Change Initiatives in Nepal

Nepal signed the UNFCCC in the Earth Summit at Rio on June 12, 1992 and ratified it on May 2, 1994. This was followed by the establishment of Environment Protection Council (EPC) under the chairmanship of Rt. Honourable Prime Minister with an ultimate objective to integrate environmental concerns in the development process. Formulation of the national policy on environment was initiated by EPC and finally approved "National Environmental Policy and Action Plan (NEPAP)" in 1994. Alternative Energy Promotion Centre (AEPC) was established under the then Ministry of Science and Technology (MoST) in November 1996 with the objective of developing and promoting renewable or alternative energy technologies to reduce poverty particularly in rural Nepal. Sustainable Development Agenda for Nepal (2003-2017) was prepared in 2003 and it was able to address climate change issues to some extent.

The issues of environment and climate change have been addressed by several legal instruments; Environment Protection Act, 2019 and Environment Protection Regulation, 2020 being the key environmental legislations in Nepal. Other legislations include Soil and Water Conservation Act, 1982; Water Resources, Act, 1992; Industrial Enterprises Act, 1992; Vehicle and Transport Management Act, 1992 and Regulation, 1997; Forest Act 2019 and Regulation, 1995; Local Governance Operation Act, 2017; and Ozone Depleting Substance Consumption Regulation, 2001.

Apart from the legal instruments, Nepal has developed and rolled out a number of plans, policies, strategies, guidelines and frameworks in response to climate change; the National Climate Change Policy, 2019; National REDD$^+$ Strategy, 2018; National Adaptation Programme of Action, 2010; Climate Resilient Planning Tool, 2011; Climate Change Budget Code, 2012;, Climate Change Financing Framework, 2017; Local Adaptation Plan for Action Framework, 2019 and Second Nationally Determined Contributions, 2020. Similarly, Long-term Low Greenhouse Gas Emission Development Strategy and National Adaptation Plan are underway. Further, climate change issues have been incorporated into various sectoral policies and strategies which are discussed in detail in section 2.4.

1.2.2 Institutional Arrangement

The GoN formed the Climate Change Council (CCC) in 2009 which was a 25-member high-level coordination body chaired by the Rt. Honourable Prime Minister including 11 ministers and eight technical experts nominated by the GoN, with the MoFE functioning as the council secretariat. It was meant to provide high-level policy and strategic oversight, coordinate financial and technical support to climate change-related programs and projects, as well as to secure measures to benefit from climate change-related international negotiations and decisions.

To coordinate climate change activities and implement collaborative programs, a multi-stakeholder Climate Change Initiatives Coordination Committee (MCCICC) was formed in 2009, with representation from the relevant ministries and institutions, international and national NGOs, academia, the private sector, and development partners. Its main aim is to strengthen multi-stakeholder collaboration in responding to climate change. It also has the task of facilitating strategic financing by providing a venue where needs are identified, articulated, and taken into account in the formulation of financing strategies by the GoN and its development partners.

With the effect of federal governance system in Nepal, there was a need to restructure this council. The government thereby opted to merge the Environment Protection Council and Climate Change Council which came into effect with the enactment of Environment Protection Act, 2019 (EPA). EPA has provisioned, in article 32, the "Environment Protection and Climate Change Management National Council" under the leadership of Rt. Honourable Prime Minister for nation-wide effective implementation of the activities related to the environment protection and the climate change. This is the apex institution to steer the climate change agenda and priorities of Nepal. The council is structured with the following members.

▪ Prime Minister	Chairman
▪ Minister, Ministry of Forests and Environment	Member
▪ Three Ministers of Federal Government appointed by the Prime Minister	Member
▪ Chief Ministers from all provinces	Member
▪ Member, National Planning Commission (Environment Sector)	Member
▪ Two Professors of Forestry and Environment Science, including one female member, appointed by the Chairman	Member
▪ Three Experts with expertise on Environment and Climate Change Sector, including two female members, appointed by Chairman	Member
▪ Secretary, Ministry of Forests and Environment	Member Secretary

Ministry of Forests and Environment (MoFE) is the lead agency to regulate country's environment, climate change, forests, wildlife, National Parks and wetlands by promulgating different Acts, policies, guidelines, rules, regulations and programmes/projects for these sectors. Under MoFE, Climate Change Management Division (CCMD) is mandated to deal with climate change issues at the international, national and sub-national levels. Institutional arrangement for climate change affairs in Nepal is presented in Figure 2[5]. Recently, Provincial Climate Change Coordination Committee (PC4) has been formulated at each Province which has multi-sectoral representation from ministries, research institution, farmers' groups, women and private sector. This committee is envisioned to coordinate matters related to climate change in the Province. However, dedicated institution to deal with the climate change is lacking at the local level.

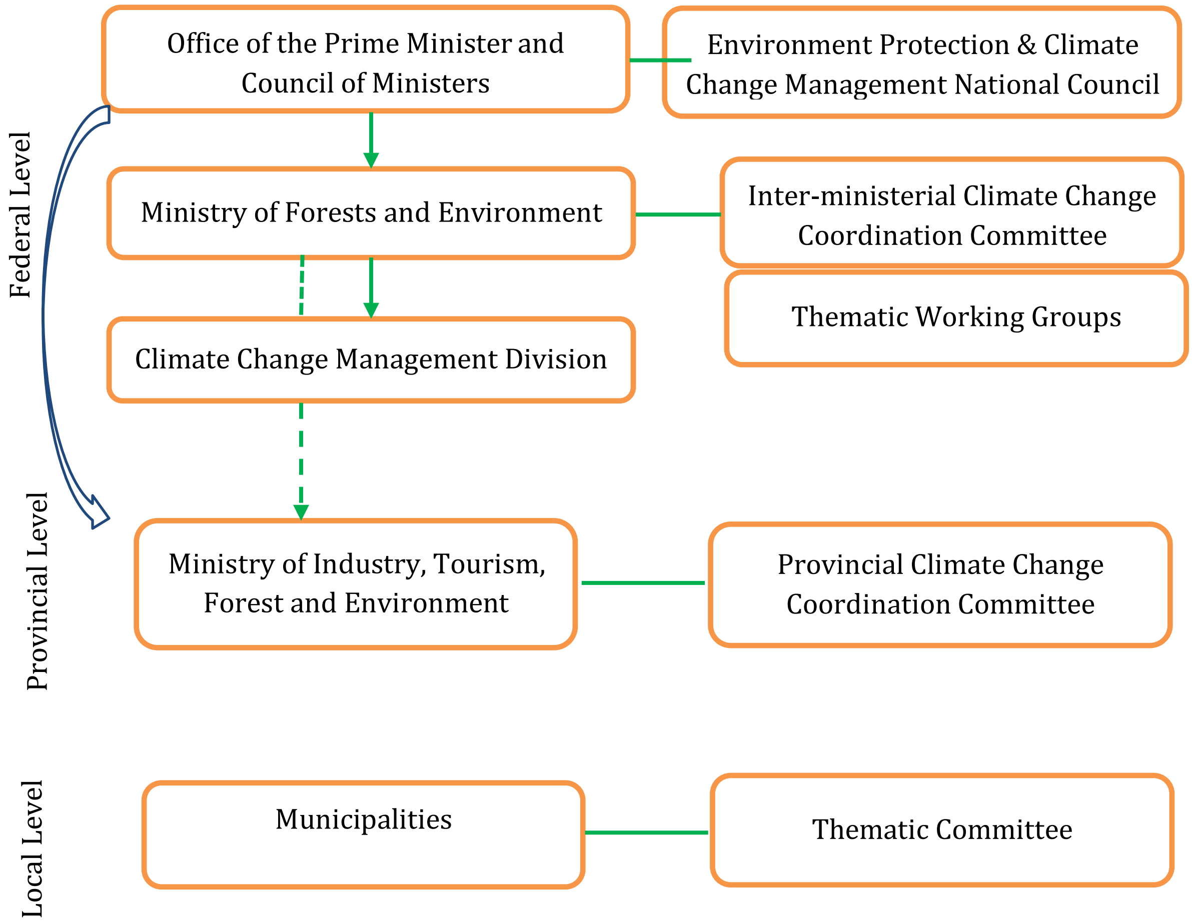

Figure 2: Institutional Arrangement for Climate Change Governance in Nepal

[5] The figure has been adopted from "MoFE (2020), Policy alignment to advance climate resilient development in Nepal: opportunities and way forward" with modifications.

1.2.3 Climate Change and GHG Emission Scenario

Nepal is one of the least developed countries with mountainous topography and agrarian based economy. Climate Change Risk Atlas 2011 released by global risks advisory firm Maplecroft ranks Nepal as the fourth most vulnerable country in the world (Maplecroft, 2011). Time series data analysis of the period 1980-2009 revealed that most of the stations maintain positive trend with maximum increase of about 15 percent of the annual amount of precipitation per decade except few stations of the western part of Nepal showing negative trend. Increasing trends of precipitation in summer days and summer nights are observed while there is decreasing trend in winter days and winter nights over most of the stations excluding the southern Tarai region. Similarly, monthly maximum one-day precipitation amount, annual count of days when precipitation of 50 mm or more falls, extremely wet days all exhibit increasing trends in most of the stations apart from mountainous stations.

Nepal's Initial National Communication[6] reports that the inventory was undertaken for the base year 1994 with emission of 39265 Gg of CO_2 equivalent (MoPE, 2004). Agriculture sector was the largest contributor (69.2%) followed by Land Use Change & Forestry sector (20.6%) and Energy (7.52%). Second National Communication (SNC)[7] reports a total emission of 13447 Gg CO_2 equivalent for the base year 2000 (MoSTE, 2014). The GHG inventory conducted for the SNC reveals that the Agriculture sector remains the largest source category for GHG emission (68.9%) followed by Energy sector (27.8%). The national GHG inventory prepared as part of the TNC reports a total GHG emission of 28166.06 Gg CO_2 equivalent for the base year 2011. According to TNC, Energy sector dominates the GHG emission with share of 52.37% followed by AFOLU sector (43.03%).

1.2.4 National Policy and Strategic Framework

a) Overarching Policies and Strategies

National Climate Change Policy, 2019 aims, with regards to climate change mitigation, to promote green economy by adopting the concept of low carbon emission development and mobilize national and international financial resources for climate change mitigation and adaptation in just manner. Under agriculture and food security sector, the policy adopts measures to promote water efficient technologies and low carbon emission and energy efficient technologies for production, collection, processing and storage.

The NCCP under water resource and energy sector encourages production and use of energy efficient technologies. The use of energy efficient technologies and electrical energy are also encouraged for use in industry, transport and physical infrastructure sector. Under the same sector, the policy also encourages use of electrical vehicles. The

[6] https://unfccc.int/resource/docs/natc/nepnc1.pdf
[7] https://unfccc.int/resource/docs/natc/nplnc2.pdf

tourism, and natural and cultural heritage sector encourages use of renewable energy and energy efficient technologies in tourist spot to materialize the concept of zero emission. The policy strategizes to receive and mobilize finance from bi/multilateral international financial mechanism like REDD+, Green Climate Fund, Global Environment Facility, Adaptation Fund, Climate Investment Fund, Carbon Trade etc.

Environment Policy, 2019 adopts several policy measures for environmental conservation, pollution control, governance etc. The policy measure on sustainable development resonates better with the climate change and technological needs point of view. The policy adopts working principles like development of bicycle and pedestrian friendly infrastructure in urban areas. Similarly, the policy also adopts measure to implement necessary provision for the use of electric vehicles.

Development Cooperation Policy, 2019 recognizes environment protection and climate change as one of the domains prioritized for international development cooperation. Aid mobilization modality prioritizes mobilization of development cooperation from established global funds in the area of climate change, among others, through grant assistance. However, the modality preconditions the framework to be prepared for disaster management, environment protection and adaptation and mitigation of climate change prior receiving such cooperation. Similarly, the section under grant assistance within the policy prioritizes sectors contributing environmental protection and climate change for grant assistance to be mobilized.

In December 2020, Nepal submitted its second NDC for the period of 2021 to 2030 pursuant to the articles 4.2 and 4.11 of the Paris Agreement. The NDC targets four sectors; Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use Change (AFOLU) and Waste. On energy sector, NDC has targeted the areas like Energy Generation, Transport and Residential Cooking and Biogas. Similarly, under AFOLU sector Forestry has been targeted and management of wastewater and faecal sludge is included under the waste sector. The quantified targets highlighted by the NDC, 2020 is summarized below:

- NDC sets target to generate 5-10 percent of the 15,000 MW clean energy generated from alternative energy sources like mini/micro-hydro power, solar, wind and bio-energy in 2030.
- For energy use in transportation, targets have been set to increase sales of e-vehicles to cover 90 percent of all private passenger vehicles including two-wheelers and 60 percent of four-wheeler public passenger vehicles in the year 2030 thereby lowering the emission by 28 percent compared to the baseline.
- Development of 200 Km electric rail network for transportation of people and goods by 2030.
- Use of electricity as primary mode of cooking in 25 percent of the households thereby lowering the emission by 23 percent compared to the baseline by 2030.

- Maintain 45 percent of the total area of the country under forest and manage 50 percent of tarai and inner tarai forest, and 25 percent of the hills and mountain forest sustainably, including through the funding from REDD+ initiatives by 2030.
- Treatment of 380 million litres/day of wastewater and 60,000 cubic meters/yr of faecal sludge thereby reducing 258 Gg CO_2 equivalent compared to the baseline.

Of the total targets included in the NDC, generation of 5,000 MW of clean energy has been set as an unconditional target which the Government of Nepal shall meet through its own resources which is estimated to be USD 3.4 billion (MoFE, 2020). All other targets are the conditional targets and the cost towards achieving these targets outlined in Nepal's NDC is estimated to be USD 25 billion. In order to meet the conditional targets outlined in the second NDC, Nepal anticipates financial, technological and capacity building support from different financing instruments that can be accessed through various global funds such as Green Climate Fund, Global Environment Facility, Adaptation Fund and LDC Fund as well as other bilateral and multilateral agencies.

b) Sectoral Policies and Strategies

Apart from the overarching policy measures discussed in previous section, several sectoral policies and strategies are formulated to support activities that are conducive to pursue climate change mitigation. The sectoral policy initiatives are crucial to identify and categorize specific technology required for specific sectors. As the sectoral policies have more focussed measures in achieving sectoral priorities, technological needs therein are crucial for comprehensive technological needs.

- ***Agriculture***

Agro-biodiversity Policy, 2006 has adopted a policy to identify, record, investigate, evaluate and map genetic resources and material tolerant to impacts of climate change. The policy aims to contribute to, among others, climate change mitigation and adaptation; however, the policy is not explicit on the specific approach for climate change mitigation. Similar is the case with Irrigation Policy, 2013 which also bases on conceptual premise to implement adaptation programs to address negative impacts imparted on water sources and their irrigational use, among others, due to climate change. This policy also doesn't specify any technology for climate change mitigation.

Agriculture Mechanization Promotion Policy, 2014 adopts policy to promote use of renewable and alternative energy such as biogas and solar energy and promote use of environment friendly and fuel efficient machinery. The stated policy measures promote renewable energy and energy efficiency in agricultural application such that the use of fossil fuel is either avoided or minimized thereby contributing to the climate change mitigation. The intervention deliberated however is targeted towards renewable energy and energy efficiency in agricultural input.

- ***Energy***

Rural Energy Policy, 2006 emphasizes development of environment friendly rural energy technologies. Similarly, the policy also emphasizes economic and industrial activities based on rural energy technologies and, development and management of new technology to increase efficiency of use of traditional energy. Working policies outline various measures to promote specific technologies such micro and small hydro power, bio-energy (including biogas, fuel-wood, charcoal, briquette, biomass energy and biomass gasification), solar energy, wind energy, improved cook stoves and improved water mill technologies). Apart from the promotion of available technologies, the policy also promotes research and development of new technologies and engagement of private and non-government sector in technology production and expansion.

National Energy Strategy, 2013 highlights renewable energy promotion and reduction of detrimental environmental impacts from energy supply and use as strategic objectives, including others. The strategy reclassifies energy resources in Nepal and outlines a number of strategies that can be developed further as carbon projects. It discourages the use of fossil fuel by promoting alternative fuels in transport and machinery. This strategy aims to gradually replace 20 and 30 percent of the demand capacity of diesel and petrol cars in year 2025 and 2030 respectively with electric and hybrid vehicles in equal share. In addition, the strategy seeks to identify, introduce and promote new and efficient biomass energy combustion devices and aims to replace 50 percent of traditional cooking stoves by ICS from 2015 to 2030 as a long term strategy. The strategy comprehends the environment for promotion of climate technologies in the areas related to transportation and cooking.

Biomass Energy Strategy, 2017, as the document itself rationalizes, is founded on the grounds to enhance access and modernize biomass energy resources and at the same time reducing dependency over imported fossil fuels. The measures adopted by the strategy includes measures to increase access to clean cooking technologies to all households and to partially substitute the utilization of diesel and petrol by bio-diesel and bio-ethanol. As working principles to the strategic measures, the strategy aims to promote utilization gas produced from waste management (landfill) site, private sector for production and marketing of improved and modern biomass energy technologies like biogas, ICS, gasifier, briquette/pellet, co-generation, waste to energy etc., generation of bio-ethanol from molasses produced from sugar mill for blending it with petrol. The strategic measures identified demand room for technological innovation and transfer.

National Energy Efficiency Strategy, 2019 recognizes energy efficiency as a measure to achieve, among others, carbon emission reduction and in minimizing negative effects of climate change. The policy rightly recognizes the opportunity and strategize to conduct activities that promote use of energy efficient equipment in transport and industrial sectors and reduce air pollution and greenhouse gas emission. Efficiency improvement measures also demand for respective technological advancements.

- ***Urban Settlement and Infrastructure***

National Urban Policy, 2007 adopts strategy to achieve clean and prosperous urban environment and promote environmentally benign system and means in public transportation. The policy specifically measures to promote vehicles for mass transportation and electrical and vehicles using alternative fuel like Compressed Natural Gas (CNG).

- ***Transport***

Environment Friendly Transport Policy, 2014 sets goals to contribute environmental conservation through reduced air pollution by reducing carbon emission due to fossil fuel combustion in vehicles and ensure at least 20 percent of all vehicles operating in 2020 are environment friendly. In order to achieve these goals, the policy has provisioned measures like conversion of vehicles used by government, non-government, diplomatic mission or individual that have remained unused due to high repair and maintenance costs to electric vehicles.

- ***Industry***

Industrial Policy, 2010 aims to establish industrial enterprise as sustainable and reliable sector through use of modern technology and environment friendly production process. As working policy, the policy has provisioned measures to provide technical and financial support to the industries that adopt environment friendly technology and achieve energy efficiency on their own initiative. Similarly, the policy also seeks to adopt special measure to promote green industry and make the existing industry pollution free and carbon neutral.

- ***Forestry***

National Forest Policy, 2019 aims to contribute from forestry sector to Nepal's overall target to reduce carbon emission. The policy strategizes improved production and use of wood products to reduce carbon emissions. Similarly, it also has adopted working principle of utilizing payment opportunities against carbon emission reductions through international mechanism from forestry sector.

The summary of technology measures prioritized in the sectoral policies is presented in Table 1.

Table 1: Summary of technology measures prioritized in sectoral policies

S.N.	Sectors	Policies and Strategies	Policy Measures
1.	Agriculture	Agriculture Mechanization Promotion Policy, 2014	▪ Renewable energy and energy efficiency measures in agricultural application
2.	Energy	Rural Energy Policy, 2006	▪ Specific working policies for development and promotion of various renewable energy technologies. ▪ Emphasis on economic and industrial activities based on rural energy technologies and, development and management of new technology.
		National Energy Strategy, 2013	▪ Aims to replace 20 and 30 percent of the demand of diesel and petrol cars in year 2025 and 2030 by electric and hybrid vehicles. ▪ Replace 50 percent of traditional cooking by ICS from 2015 to 2030.
		Biomass Energy Strategy, 2017	▪ Measures to increase access to clean cooking technologies to all households. ▪ Measures to utilize gas from the landfill site ▪ Strategizes production and marketing of modern energy technologies through technological innovation and transfer.
		National Energy Efficiency Strategy, 2019	▪ Strategizes energy efficiency in transport and industrial sectors.
		Environment Friendly Transport Policy, 2014	▪ Policy measures for vehicle conversion. ▪ Target to ensure at least 20 percent of all vehicles operating in 2020 are environment friendly.
4.	Industry	Industrial Policy, 2010	▪ Measures to provide technical and financial support to industries that adopt environment friendly technology and energy efficiency.
5.	Waste	National Urban Policy, 2007	▪ Policy measures for promotion of electric and CNG based vehicles for mass transportation.

CHAPTER-2: INSTITUTIONAL ARRANGEMENT AND STAKEHOLDER ENGAGEMENT

2.1 Institutional arrangement of Nepal TNA project

The implementation of the TNA project in Nepal involved participation of multiple government agencies, research institutions (both public and private), and non-governmental organizations. The Figure 3 shows the institutional arrangements of the TNA project.

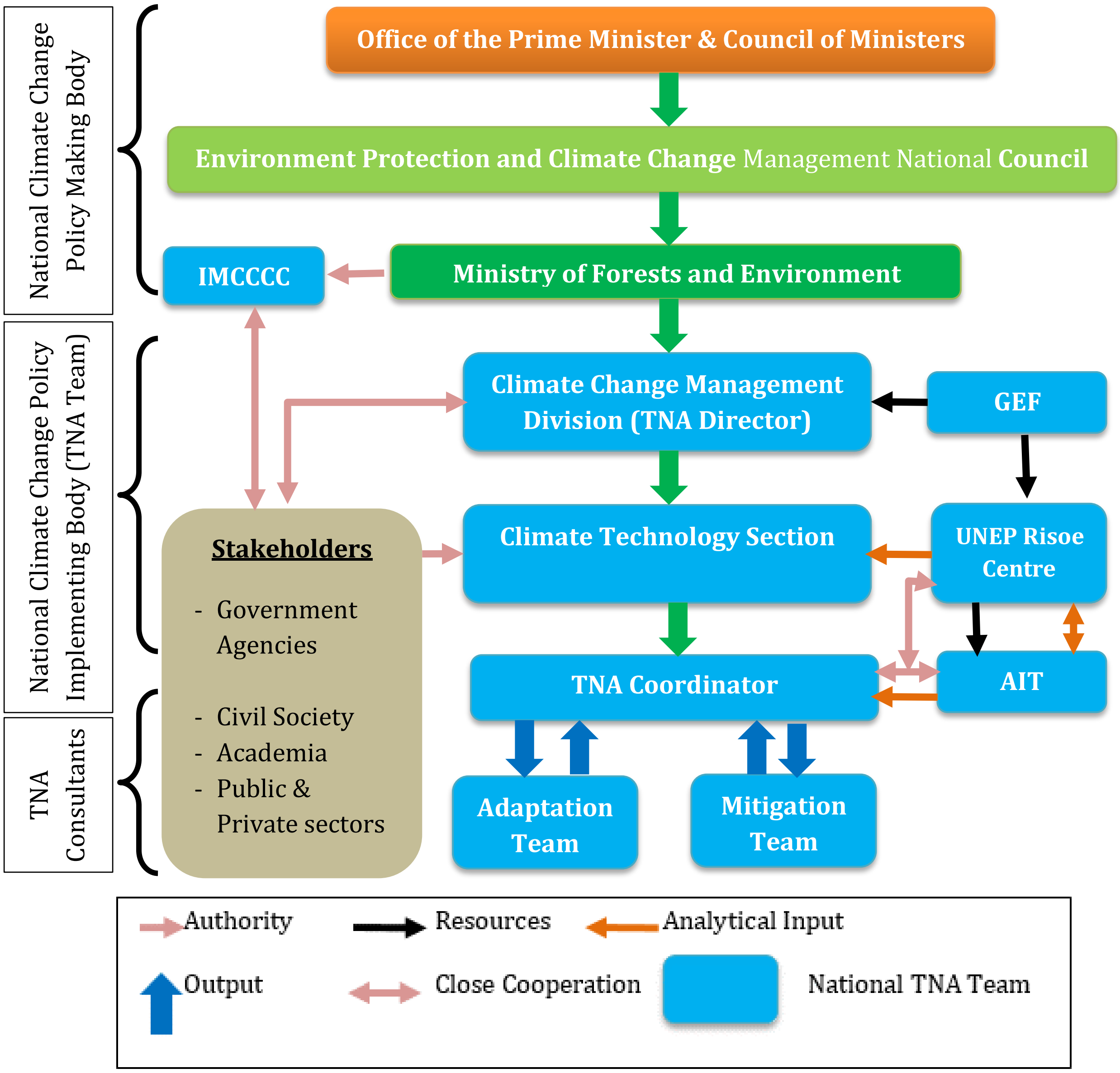

Figure 3: Institutional Arrangement for the TNA Project

The National Supervising Agency: Environment Protection and Climate Change Management National Council and Inter-Ministerial Climate Change Coordination Committee.
National Coordination Institution/Executing Agency: Ministry of Forests and Environment
Climate Change Management Division: TNA process was led by Climate Change Management Division within MoFE.
Climate Technology Section: TNA process was managed and executed by the Climate Technology Section.

2.1.1 National Project Coordinator, National TNA Team and Consultants

The role of the Project Coordinator was taken by Under Secretary (tech.) level staff heading the Climate Technology Section under the Climate Change Management Division of MoFE. He was responsible for overall TNA process which include facilitating the tasks of communication with the National TNA Team members and managing outreach to stakeholders, formation of networks, information acquisition, and coordination and communication of all work products.

The TNA Consultant Team comprised two groups of experts: mitigation and adaptation. The team included members familiar with national development objectives and sector policies, better insights in climate change science, and potential climate change impacts, adaptation needs and mitigation options of climate change technologies. The experts represented institutions with expertise on policy-making and organizations with responsibility to undertake TNA activities such as research, analyses and synthesis in support of the TNA exercise. Specifically, the TNA consultant team included the following:

- Identification and categorization of the country's priority sectors, and identification and prioritization of technologies for mitigation through a participatory process engaging with relevant stakeholders,
- Lead the process of technology needs assessment, identifying assessment criteria, and identifying and addressing the barriers
- Prepare TAP report with climate mitigation component – a roadmap of policies that provides enabling framework to overcome the barriers
- Develop Project Idea for immediate application of the technology

2.1.2 The Cooperation of UNEP Risoe Centre and AIT

UNEP Risoe Centre (now the UNEP DTU Partnership) and AIT experts provided their valuable guidance in devising the whole process of technology needs assessment. In coordination with the Ministry a two days training was organized for the Mitigation and Adaptation team experts in defining the TNA process, use of Multi-Criteria Decision

Analysis (MCDA) tool, workouts of other countries and the documents to supplement the TNA report of Nepal.

2.2 Stakeholder Engagement in the TNA Process

The whole TNA process envisages stakeholders as the major contributor towards the finalization of the TNA. Hence every step involved large share of stakeholders for making pioneering decisions in finalizing the TNA. The roster of stakeholders involves policy-making government agencies, research institutes and centres (ICIMOD, Institute of Engineering, Institute of Agriculture and Animal Sciences, Department of Hydrology and Meteorology, Forest Action Nepal, College of Applied Sciences and Alternative Energy Promotion Centre), and public and private organizations (National Federation of Environmental Journalist, USAID, Confederation of Nepalese Industries, Trust-Nepal, Great-Nepal, and ADB).

The PMU, National Consultant Team and stakeholders cooperated in the overall TNA process. The stakeholders were informed about the process and objectives of TNA activities in the inception workshop held in presence of UNEP official:

- The national team, after completing necessary studies (national priorities, plans, policies and strategies) and establishing appropriated criteria for selection of sectors and sub-sectors, consulted with PMU for stakeholder consultation in assessing the priority sectors/ sub-sectors. The findings of the national team were thus shared with all stakeholders in the prioritization workshop. The suggestions and comments were collected and incorporated in the sector prioritization report.
- PMU organized technology prioritization workshop after necessary consultation with the experts. Long list of technologies was shared among the stakeholders and thorough iterative discussion following MCDA approach, the technologies were prioritized.

Throughout the TNA process, these core bodies interacted and discussed to carry out assessment in an objective fashion in identification, assessment and selection of climate appropriate technologies. The national team received enthusiastic support from stakeholders in completing the requirement of TNA and sectoral data in meeting the objectives of TNA.

CHAPTER-3: SECTOR SELECTION

TNA handbook was referenced to complete the TNA process. As per the handbook, review of national GHG inventory was carried out based on the available inventory report. While conducting the assessment in 2014, Initial National Communication submitted by Nepal was the only source of GHG inventory and hence that was referenced. Considering the fact that while updating the TNA report in 2020, the GHG inventory reports for the third national communication are available as well as the second NDC has been submitted, for any quantitative estimate related to the GHG, findings of the GHG inventory from TNC has been referenced. However, for the qualitative information as the AFOLU and Energy has remained the key contributors in Nepal's national GHG emission across the three national communications prepared, no changes are deemed necessary. For the purpose of assessment, the sectors and sub-sectors were identified considering GHG inventory and development priorities, and identification of key GHG emitting sectors was done which were in line with the development programmes and policies of Nepal. In this process, sectoral policies and plans were reviewed in brief to understand the expected future growth in GHG emissions, long term mitigation potential, socio-cultural, economic and development priorities.

3.1 An overview of sectors, projected climate change, and GHG emissions status and trends of the different sectors

3.1.1 Overview of the Emission Sources and Sinks

The total net emission of the main GHGs of Nepal in 2010/11 has been calculated to be 28166.06 Gg of Carbon dioxide equivalent. Net removal of 16231.43 Gg of CO_2 is reported in the GHG inventory for the base year 2010/11 prepared as part of the TNC. The total Methane (CH4) emissions were estimated at 1259.61 Gg in 2010/11 with AFOLU sector contributing more than 70 percent of such emission and almost 80 percent of CH_4 emission in the AFOLU sector being contributed by enteric fermentation in the livestock. Similarly, AFOLU sector was also the major contributor of the N_2O emissions sharing 80.5 percent of the total emission. Rest of the N_2O emissions resulted from the energy sector (14.85%) and waste sector (4.65%). The GHG inventory carried out for the base year 2010/11 also revealed that 0.01 Gg of the Hydrofluorocarbon (HFC) was emitted and emission of this gas was solely contributed by the Industrial Processes and Product use (IPPU) sector. Table 2 summarizes the GHG emissions and removals resulting from national GHG inventory for base year 2011.

Table 2: Summary Table of Nepal's GHG emission and removal 2010/11 for direct gases

Sector, Sub-sectors	Emission/Sink of Direct Gas (Gg)				
	CO_2	CH_4	N_2O	HFC*	CO_2-eq
TOTAL	**-11195.02**	**1259.61**	**26.37**	**0.01**	**28166.06**
1 Energy	**4678.22**	**354.9**	**4.03**	0	**14751.66**
- Energy Industries	2.38	0	0		2.38
- Manufacturing Industries and Construction	2237.34	0.04	0.06		2256.22
- Transport	1708.92	0.27	0.08		1739.51
- Others (Commercial/Institutional, Residential, Agricultural)	729.58	354.59	3.89		10753.55
2 Industrial Processes and Product Use	**355.4**		**0**	**0.01**	**368.4**
3 AFOLU	**-16231.43**	**882.36**	**21.12**		**12121.33**
- Livestock		705.49	0.09		17664.07
- Land (Forest)	-17077.81				-17077.81
- Land (Non-forest)	35.39				35.39
- Aggregate Sources and Non-CO2 Emissions Sources on Land (3C)	810.99	176.87	21.03		11499.68
4 Waste	**2.36**	**22.35**	**1.22**		**924.67**
Memo Items					
International Bunker	**172.51**				
Biomass Combustion for Energy Production	**23,499**				

(Source: Nepal's Third National Communication to the UNFCCC, 2021)

3.1.2 Energy Sector

i. Overview

Nepal's energy consumption per capita is one-third of the Asian average and less than one-fifth of the world average. Until recently, Nepal was facing challenges in meeting its energy demands. The per capita energy consumption, as per the World Bank estimate, was 434.45[8] Kg of oil equivalent in 2014 which is one of the lowest in South Asia. The World Bank estimate for the same year reports, with each Kg of oil equivalent used, Nepal is able to produce 5.96 USD which is around 60percent of South Asian average (9.71 USD) for 2014. The disparity in consumption of energy and production of GDP is an indication for one of the two things; either better economic growth may be achieved with the same level of input energy or the same level of economic growth can be maintained with reduction of input energy. In either case, there is clear scope for efficiency improvement that will result in the reduction of GHG emissions.

Total energy consumption in the year 2008/09 was about 9.3 million tonnes of oil equivalent (401 million GJ) in the country out of which 87 percent were derived from traditional resources, 12 percent from commercial sources and less than 1percent from

[8] https://datacommons.org/place/country/NPL?topic=Environment accessed on 17 Dec 2020.

the alternative sources (WECS, 2010). As the larger fraction of the population fulfils its energy need from the traditional resources, it is imperative to address the technological needs and innovation in traditional energy production and supply system to address overall issues and challenges of energy sector.

ii. <u>Energy Resource Base</u>

The three major resources of energy in Nepal are biomass, hydropower and solar. There are some sporadic deposits of natural gases and coal reserves, but they are yet very small in quantity and still not exploited commercially. The potential of known energy resources in Nepal is estimated to be 1970 million gigajoule (GJ) annually on a sustainable basis (WECS, 2006), which would be 15 times the estimated total consumption. Of the total sustainable potential, water resources represent the largest fraction (75%), with forests contributing 12 percent and the rest coming from other sources like solar energy, wind energy and petroleum products (WECS, 2006). Though Nepal has a huge potential of hydropower production, its exploitation has been very minimal, and therefore, it is the biomass sector which dominates the overall energy supply and consumption. Biomass is the major sources of energy in Nepal. It consists of both woody and non-woody biomasses. Fuel wood is the main source of energy and represents 77.7 percent of the total energy consumption of Nepal (WECS, 2010).

Traditional Energy

Traditional sources of energy have a major share in the energy demand and its consumption in Nepal. Under this category the energy derived from Firewood, Agricultural Residue and Animal Dung are considered. According to the census result, 3.47 million households rely on firewood and 0.56 million on cow dung for meeting their cooking need (CBS, 2011a). The consumption of traditional sources of energy stood at 68.7 percent in the first eight months in Fiscal Year (FY) 2019/20 (MoF, 2020). Of the traditional energy consumption, the share of fire wood was 91 percent, agriculture residue was 4 percent and dung cake was 5 percent during the same period (MoF, 2020). Firewood is the primary fuel used for cooking in most rural parts of the country. Overall, 64 percent of households use firewood and a significant proportion of households in Tarai use cow-dung/leaves/straw/thatch as the main source of cooking fuel. Apart from the primary source of cooking fuel, firewood is used for other purposes, such as heating the house and preparing animal feed. About 65 percent households collect firewood from the forests while 24 percent collect from their own land (CBS, 2011b).

Commercial Energy

Energy derived from the Coal, Petroleum Products and Electricity are collectively called commercial energy in Nepal. Commercial energy occupied 28.04 percent share of total energy consumption in the first eight months of the FY 2019/20 (MoF, 2020). Of the total commercial energy consumed, 65 percent was supplied by the petroleum products followed by coal (21%) and electricity (14%).

Nepal has no petroleum reserves and hence all the petroleum products are imported. Diesel, petrol, aviation turbine fuel (ATF) and liquefied petroleum gas (LPG) occupy a major share of petroleum products consumed. Total import of petroleum products; viz, petrol, diesel, kerosene and ATF stood at 2.5 million kilo litre in FY 2018/19 while in the same period, 0.43 million metric ton of LPG was imported (MoF, 2020). National census conducted in 2011 reveal that LPG and Kerosene are used mainly as cooking fuel with 1.1 million households using LPG and 55610 households using Kerosene for cooking purpose. Use of kerosene has decreased as a cooking fuel from 13 percent of the total energy consumption in 2001 to 1 percent in 2011, while use of LPG has increased from 8 percent to 21 percent in the same period (CBS 2011a). Similarly, use of kerosene decreased from 58 percent in 2001 to 18 percent in 2011 as fuel for lighting (CBS 2011a).

With regards to electricity, hydropower is the dominant source of electricity generation in Nepal. A major portion of electricity is supplied by hydropower plants owned by Nepal Electricity Authority followed by Independent Power Producers. Electricity is also being imported from India. According to the economic survey 2019/20, by February 2020, 90 percent of the population has access to electricity which was 88.0 percent by the end of FY 2018/19. By the first eight months of fiscal year 2019/20, the number of consumers using electricity have reached 4.15 million. The power generated in first eight months of fiscal year 2019/20 has increased by 8.3 percent to 1,355 MW compared to 1251 MW, the total electrical power generated in 2018/19. Out of the generated electricity, 1233 MW is from hydroelectricity, 54 MW from thermal plant and 68 MW from renewable energy.

In the fiscal year 2018/19, the import of electricity from India was 2813.07 GWh, but in the current fiscal year 2019/20, the import of electricity has decreased by almost half to 1468.77 GWh. With the increase in domestic production of electricity, the demand for electricity imported from India has been declining (MoF, 2020).

Renewable Energy

Energy generated by the renewable energy generation units such as mini/micro hydropower, solar, wind, biomass, biogas or combination of these are termed as renewable energy in Nepal. Use of renewable energy in Nepal is in a rising trend. This form of energy shared 3.2 percent of the total energy consumption in the first eight months of the FY 2019/20 which was 2.1 percent in the FY 2018/19 (MoF, 2020). The technological measures available in the renewable energy sector and the situation where the 68.7 percent of the total energy supply is still being met by the traditional energy resources like solid biomass, make it a potential sector where the new technological intervention can be penetrated for enhanced energy access. The technical potential of different renewable energy resources of Nepal is presented in Table 3.

Table 3: Commercial potential of various Renewable Energy technologies

SN	Technology	Commercial Potential	Reference
1	Solar	2100 MW	WECS, 2013[9]
2	Wind	3000 MW	
3	Biogas	1 Million households	
4	Improved Cooking Stoves	3.75 Million households	WB, 2017[10]

iii. Sectoral Consumption of Energy

Sectoral energy consumption in Nepal is skewed towards the residential sector. Energy data sheet published by WECS in 2014 depicts that out of 376.3 million GJ, 302.4 million GJ energy is consumed in residential sector. It is followed by industrial sector that consumes 29.7 million GJ and transportation sector that consumes 26.8 million GJ energy. Similarly, commercial sector is reported to consume 12.9, agriculture 4.4 and others 0.1 million GJ of energy. The sectoral energy consumption is presented in Figure 4.

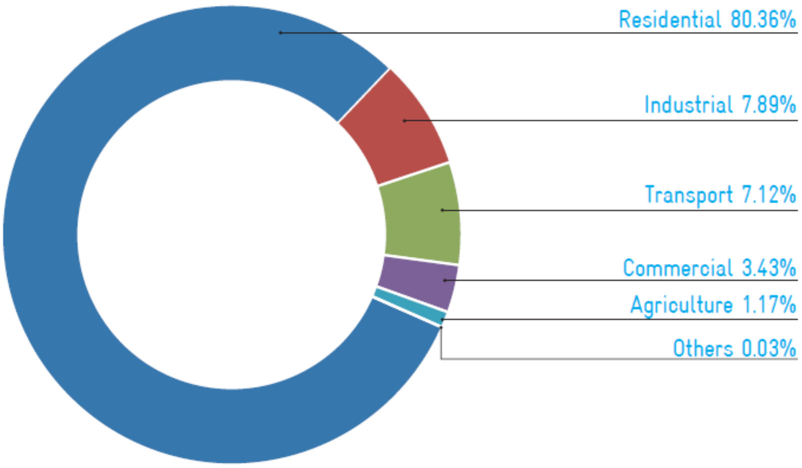

Figure 4: Energy consumption by economic sector (source: WECS, 2014)

Residential sector (households) is the primary consumer of energy in Nepal. Household energy consumption as per the Economic Survey 2018/19 stood at 42.6 percent in the first eight months of the FY 2018/19 followed by Industrial sector (38.3%). The households in the country have more affinity towards solid fuels (fire woods) as primary fuel for cooking followed by the use of Liquefied Petroleum Gas (LPG). Usage of LPG is in increasing trend during the last few years not only in the urban households and commercial sector, but also in rural areas. However, household's heavy reliance on traditional energy sources (solid fuels) remains unchanged with around 69percent population still relying on solid biomass for coking in FY 2018/19. Energy consumption mix in the first eight months of the FY 2018/19 depicts high dominance of traditional fuels (68.6%). During the first eight months of FY 2018/19, the total energy consumption

[9] WECS (2013): National Energy Strategy of Nepal.
[10] WB (2017): Investment Prospectus for Clean Cooking Solutions in Nepal.

in household, industrial, trading and other sectors stood at 42.6 percent, 38.3 percent, 7.4 percent and 11.7 percent respectively (Figure 5).

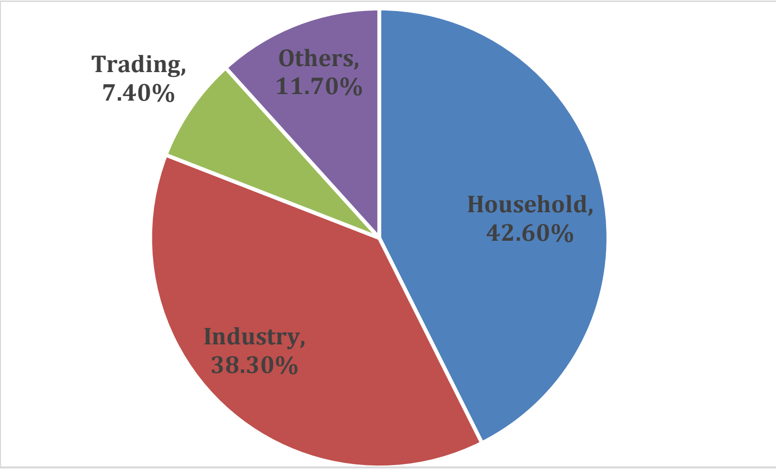

Figure 5: Sectoral energy consumption for FY 2018/19

Residential sector is followed by industrial sector with a total energy consumption of 29.7 million GJ which is about 7.89 percent of the total energy consumed for 2011/12 (WECS, 2014). Energy in the industrial sector is mainly used for the process heating accounting for 64 percent of the total energy consumed followed by motive power (22%), boiler application (9%), lighting (3%) and process cooling (1%). Remaining 1 percent of energy is used for other purposes. Energy consumption in industrial sector is presented in table 4.

Table 4: Energy consumption pattern in industrial sector

Uses	**Energy Consumed ('000 GJ)**	**Weightage (%)**
Process Heating	18,915.41	64
Power motives	6,493.08	22
Boiler	2,616.06	9
Lighting	935.89	3
Process cooling	282.28	1
Others	497.06	2
Total	**29,739.78**	**100**

(Source: WECS, 2014)

Similarly, significant quantity of energy imported in Nepal is consumed by the transport sector. In the year 2010/11, this sector accounted for the consumption of 26.8 million GJ (7.12%) of total energy consumed while the sector shared 57.9 percent of the total consumption of petroleum imported in the same year (WECS, 2014). Diesel takes the highest share with 59.88 percent followed by motor spirit with 24.36 percent share and ATF with 14.85 percent. LPG contributes with 0.82 percent of energy requirement in this sector (Figure 7).

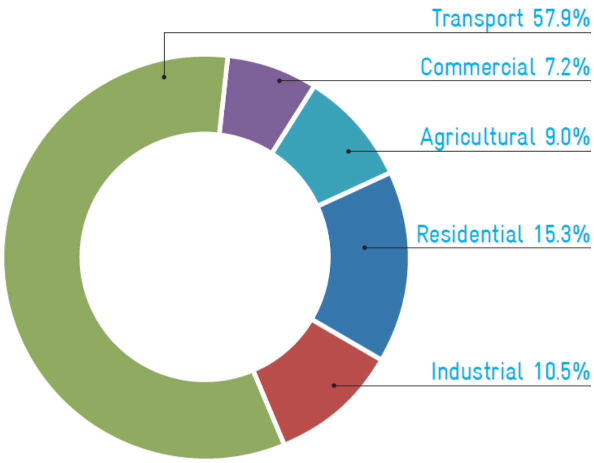

Figure 6: Consumption of petroleum across sectors (source: WECS, 2014)

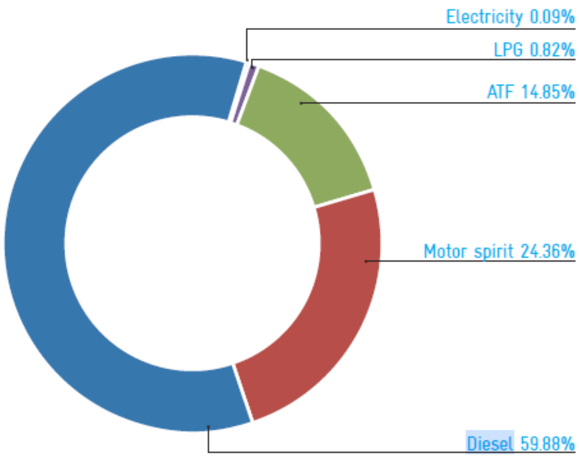

Figure 7: Energy consumption in transport sector by fuel type (source: WECS, 2014)

3.1.3 Agriculture Sector

i. Overview

Contribution of agriculture sector to GDP has been decreasing whereas that of non-agriculture sector has been increasing over the last decade. In FY 2010/11, the contribution of agriculture sector to GDP was 37.1 percent which fell to 27.7 percent (combined with forest and fisheries) in FY 2019/20. The contribution of agriculture and non-agriculture sector to GDP were 27.5 percent and 72.5 percent respectively in fiscal year 2018/19 (MoF, 2020). Compared to that of the last fiscal year, the structure of agriculture and non-agriculture sector is slightly changed this year. The involvement of population in the agricultural sector is gradually declining due to the increasing use of technology and professionalism in agriculture and expansion of service sector. According to the Nepal Labor Force Survey of 2008, 73.9 percent of the population was engaged in agriculture sector, but in 2018 the proportion has decreased to 60.4 percent (MoF, 2020). As stated, use of available modern technologies is one of the reasons for declining population active in agriculture sector. Better mechanization of the agriculture sector and improvement in cropping and livestock raising practices still provides room for low carbon agricultural practices.

ii. Crops and Livestock

The production area of food crops has declined by 0.9 percent in fiscal year 2019/20 compared to the previous fiscal year. The area of arable land has decreased due to fragmentation of land, use of arable land for housing and migration of youths abroad causing labour shortages. As rice is a staple food for almost the entire population in the country, paddy is an important crop to discuss. Paddy has two fold importance; first, it represents more than half of all the cereal crops produced in Nepal and secondly, paddy cultivation is one of the major contributors of GHG emission in Nepal.

Of the 10.69 million metric tonnes of cereal crops produced in Nepal in the FY 2019/20, paddy alone was produced in the quantity of 5.61 million metric tonnes (52.47%). Specific to paddy, the productivity has increased by 1.1 percent in FY 2019/20 (Figure 8) owing to the availability and use of improved variety of seeds, longer than average monsoon, easy availability of the fertilizers and improvement of irrigation system (MoF, 2020). As the paddy cultivation are mainly done under flooded condition, the practice trigger anaerobic decomposition of organic materials producing methane. Hence, greater the cultivation area higher the emissions.

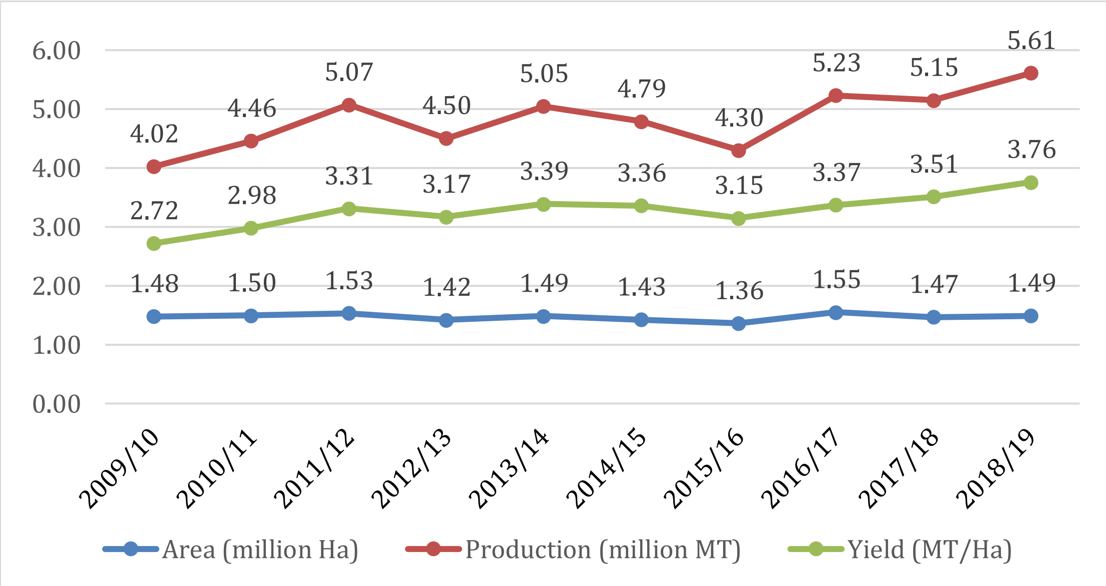

Figure 8: Paddy cultivation and production over the decade[11]

Economic survey 2019/20 reports a decline in number of dairy buffaloes, rabbits, *yaks/naks/chauri* and horses/mules/donkeys whereas the number of cows/ox, buffaloes, sheep, goats, pigs, chickens and ducks, dairy cows and hen/ducks that lay eggs have increased. Livestock are important agricultural commodity and this sector is slowly gaining the pace of commercialization. The livestock farming in Nepal is still fodder based which result in lower level of emission compared to the feed based intensive farming. But with commercialization, it will not be possible to completely rely on fodder to feed the livestock in near future. Table 5 presents the trend of population of major livestock as published in economic survey 2019/20.

Table 5: Trend in population of major livestock category

Livestock Category	Population of major livestock category (in million) in each fiscal year				
	2014/15	2015/16	2016/17	2017/18	2018/19
Dairy Cow	1.03	1.03	1.03	1.04	1.08
Other Cattle	7.24	7.30	7.35	7.38	7.39
Buffalo	5.17	5.17	5.18	5.18	5.31
Sheep	0.79	0.80	0.80	0.80	0.80
Goat	10.25	10.99	11.17	11.29	12.28
Swine	1.20	1.29	1.33	1.35	1.49

[11] Graph created using data published on "Statistical Information on Nepalese Agriculture 2075/76".

Livestock is one of the key contributors to the agriculture sector GHG emission. During the process of enteric fermentation, methane is produced from rumens as the by-product of the microbial fermentation. Similarly, the breakdown of livestock excreta under anaerobic condition further releases methane into the atmosphere. Methane emission from enteric fermentation is usually higher than that from manure management but the methane emission from manure is easier to manage compared to that from enteric fermentation.

iii. Fertilizer Use

Synthetic fertilizers like urea, di-ammonium phosphate and potash are the most commonly used nutrient supplements to improve agricultural production in Nepal (Figure 9). There is no manufacturing plant of such fertilizers in Nepal and anything that comes, is subsidized by the Government of Nepal. Urea is the key nitrogenous fertilizer commonly used in Nepal for the production of rice. Changes in quantity of the fertilizer imported therefore has direct relation with the amount of subsidy allocated by the government for fertilizer import. Soil application of the urea, during fertilization, leads to a loss of CO_2 that was fixed in the industrial production process. Urea gets converted into ammonium, hydroxyl and bicarbonate ions in presence of water and urease enzymes and further bicarbonate that is formed breaks into CO_2 and water.

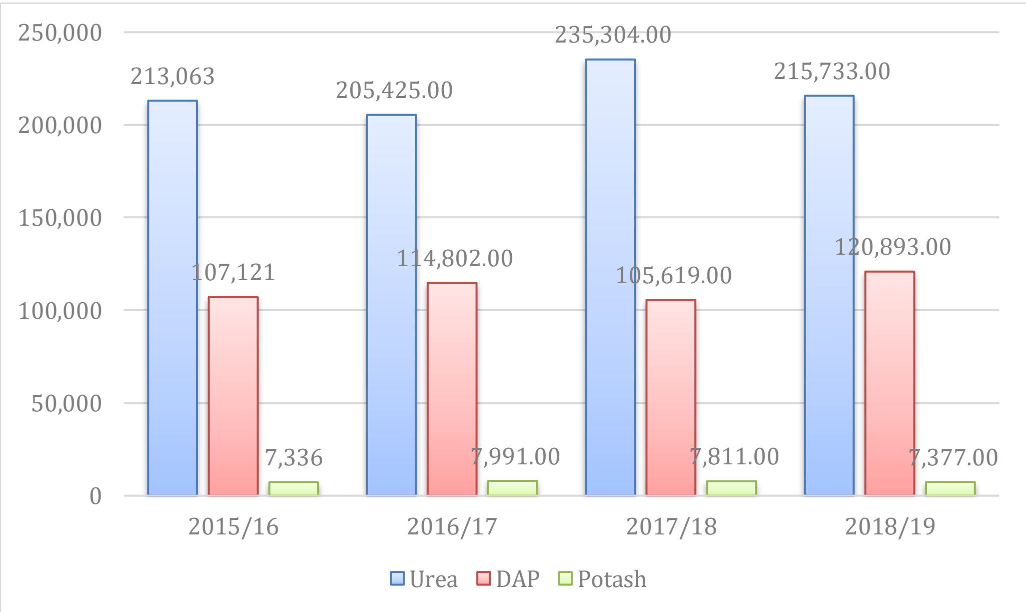

Figure 9: Trend of import of synthetic fertilizers (in Metric Tonnes)

3.1.4 Waste Sector

Domestic and commercial solid waste management system as well as domestic and industrial wastewater handling practices has profound influence on the greenhouse gas (GHG) emission in the waste sector. In respect to solid waste management and wastewater handling practices, the conspicuous greenhouse gas emission is Methane (CH_4). The indirect Nitrous oxide (N_2O) emission due to nitrification and de-nitrification of ammonium-nitrogen (NH_4-N) present in human sewage is also accounted.

Solid waste disposal in Nepal takes place in two distinctively different ways. In the rural areas and small towns, there is no systematic collection of waste and it is haphazard. In absence of anaerobic conditions, methane is not generated in these areas. However, in the urban areas, solid waste is disposed in open dumps, river banks and, in some towns, by land filling in low-land areas located in and around the urban centres. Due to stacking of the waste over the years, anaerobic conditions develop, and hence these solid waste disposal sites generate large quantities of biogas containing a sizeable proportion of methane.

Domestic and commercial wastewater are handled in such a way that they are usually discharged into the open pits/latrines, aerobic shallow ponds, and streams and rivers with few exception of discharging in septic tanks and deep lagoons. Similarly, industrial wastewater handling practice is also not much different than the domestic and commercial one. Both domestic and industrial wastewater can be of significant importance in terms of GHG emission in Nepal.

3.1.5 Forestry Sector

Forest is one of the most important resources for Nepal and it is a major form of land-use occupying 5.98 million hectares (40.36%) of total area of the country (DFRS, 2015). The contribution of agriculture, fisheries and forestry combined to the national GDP was 27.7 percent in FY 2019/20. Forest Act, 2019 classifies forests into government managed forests, protected forests, community forests, leasehold forests, religious forests and collaborative forests. There are 22,415 community forest users groups managing almost 2.3 million hectares (38.5%) of total forest area (MoFE, 2019). Forests provide ecosystem services to the world that we all benefit from. These services are categorized into four groups which are supporting, provisioning, regulating and cultural services (like biodiversity, fuel wood, water, tourism, etc.)

The latest Forest Resource Assessment Report shows that total forest area is 5.98 million hectares while other wooded land occupies 0.65 million hectares of land (DFRS, 2015).

Table 6: Trend in forest cover change

Forest Cover Type	Unit	Years			
		1978[a]	1986[a]	1994[b]	2014[c]
Forest	Area ('000 Ha)	5616.8	5504.0	4268.0	5 962.03
	%	38.0	37.4	29.0	40.36
Shrubland	Area ('000 Ha)	689.9	706.0	1560.0	0
	%	4.7	4.8	10.6	0
Other Wooded Land	Area ('000 Ha)	0	0	0	647.89
	%	0	0	0	4.38
Total	Area ('000 Ha)	6307.7	6210.0	5828.0	6002.39
	%	42.7	42.2	39.6	44.74

[a] *GoN/ADB/FINNIDA, 1988,* [b] *DFRS, 1999,* [c] *DFRS, 2015*

3.1.6 Waste Sector

A study conducted by Asian Development Bank (ADB) in 2013 reveal that the daily average per capita household solid waste generation in Nepal is 170.12 grams while the average municipal solid waste generation is 317.22 grams/capita/day. Organic waste dominates the overall solid waste composition at household waste generation accounting 66.37 percent of total waste. Similarly, it represents 21.73 percent and 43.24 percent respectively in the institutional and commercial solid waste stream. Of the total 58 municipalities covered by the study, only six municipalities were found to have sanitary landfill as the final method of the waste management while five municipalities were adopting the practice of controlled dumping. Remaining municipalities were found to practice either open dumping or river side dumping of the solid waste management. Although the sanitary method of landfilling has higher potential for generation of methane, it is a better choice over other forms from the public health and other environmental concerns.

With regards to domestic and commercial wastewater, studies have shown that sanitation coverage in Nepal increased from 30 percent in 2000 to 43 percent in 2010 (DWSS, 2011). The types of sanitation facilities were pit latrines, septic tanks, and sewerage connection. In rural areas, almost all toilets have pit latrines, whereas, in urban regions, a mixed percentage of pit latrines, septic tanks, centralized treatment plants and river disposal were in use. In the Kathmandu Valley, only 43,000 septic tanks were operational in 2000 (Green et al., 2003), whereas about 77,000 septic tanks were functional in 2008 (ADB, 2010). Those households that did not have septic tanks were mostly connected to sewerage lines, which finally disposed discharge into the rivers without any treatment. Guheshwari Wastewater Treatment Plant is by far the only prominent facility dedicated for the treatment of wastewater in Nepal.

3.2 GHG Emission Status and Share of Different Sectors

The inventory of greenhouse gases for the year 2010/11 used the 2006 IPCC Guidelines for National Greenhouse Gas Inventories to undertake the inventory of mainly three gases namely carbon dioxide, methane and nitrous oxide. The inventory reveals that total net GHG emission for the base year 2010/11 was 28166.06 Gg of CO_2 equivalents. The most prominent contributors to this are the Energy sector accounting for 52.37 percent of total emissions and AFOLU sector accounting for about 43 percent of the total emission. Rest is contributed by waste (3.28%) and IPPU (1.29%). Figure 10 presents the synopsis of the Nepal's GHG emission (Gigagram) for the base year 2010/11.

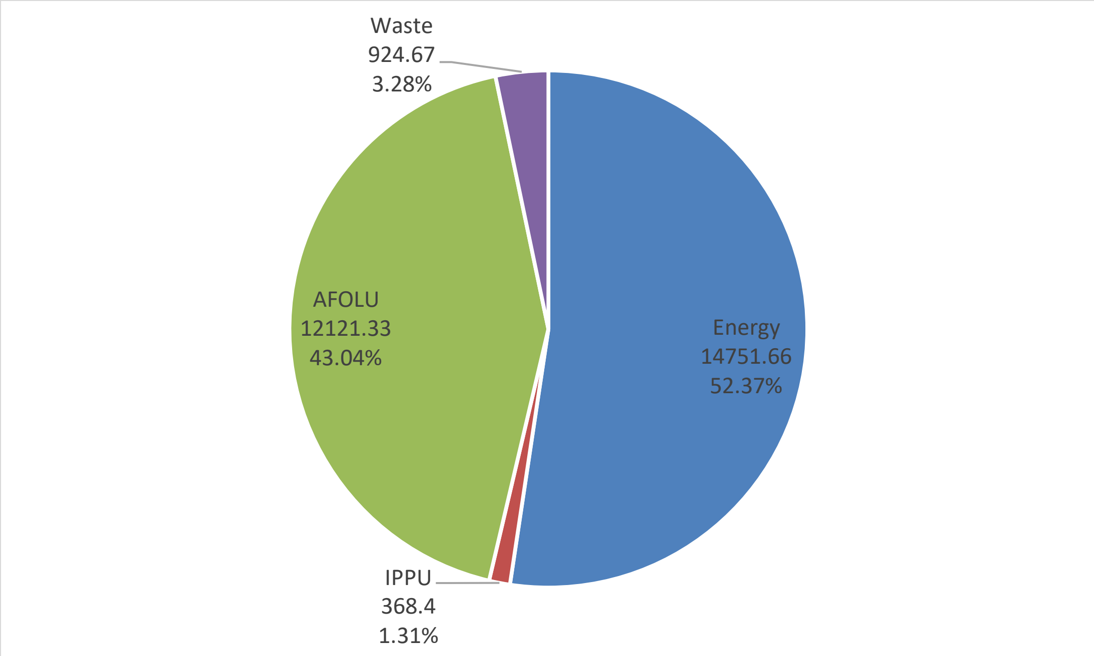

Figure 10: GHG emission (Gg) share by different sectors (2010/11)

3.2.1 Energy Sector

Energy Sector accounted about 14703 Gg of GHG emission (CO2-eq) in Nepal. The various contributors to the GHG emissions within this sector are summarized in Table 7.

Table 7: Summary of GHG emission from energy sector

Categories		**CO_2**	**CH_4**	**N_2O**	**CO_2-eq**
1 ENERGY			**Tonnes**		**Gg**
1A	Fuel Combustion Activities				
1A1	Energy Industries	2376.07	0.09	0.02	2.38
1A2	Manufacturing Industries and Construction	2237336.52	39.40	60.06	2256.22
1A3	Transport	1708915.97	274.02	79.72	1739.52
1A4	Others	729575.70	354593.88	3889.65	10753.54
Grand total (in tonnes)		4678204.26	354907.39	4029.45	14751.67
Grand total (in Giga grams)		**4678.20**	**354.91**	**4.03**	**14751.67**
Categories		**CO_2**	**CH_4**	**N_2O**	**CO_2 eq**
MEMO ITEMS			Tonnes		Gg
	International Bunker	172,507.58	1.21	4.83	173.98
Categories		**CO_2**	**CH_4**	**N_2O**	**CO_2 eq**
		Gg			
INFORMATION ITEMS	CO2 from Biomass Combustion for Energy Production (Gg)	23,499			

(Source: Nepal's Third National Communication to the UNFCCC, 2021)

It can be seen from the Table 7 and Figure 11 that manufacturing industries are the largest contributor to the CO_2 emission followed by Transport and Other Sectors. The contribution of Energy Industries is the lowest, however when the total GHG emission is compared (Figure 12), the Other Sector has the largest contribution. The Other sector includes commercial, institutional, and residential sub sectors, which burns large amount of biomass (in domestic stoves, heating furnaces and open fires) due to which, significant amount of CH_4 and N_2O are released along with CO_2. This contributes to considerable portion of GHG released by energy sector. The amount of CO_2 emitted by biomass combustion for energy related activities is substantially higher than fossil fuel combustion (23499 Gg vs. 4678.20 Gg). However, the former is not added to the national emission total. High amount of CH_4 and N_2O emissions from biomass result into high national GHG emissions (14751.67 Gg).

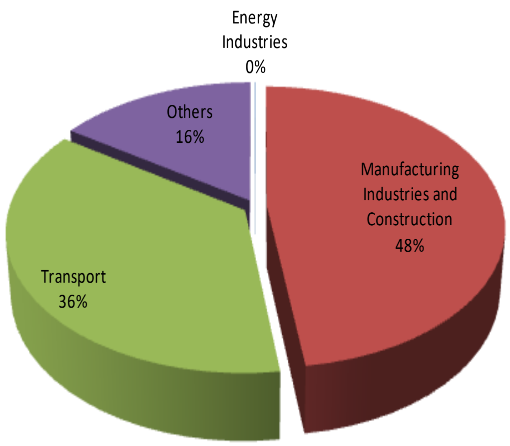

Figure 11: Share of CO2 (in Gg) by various energy sectors

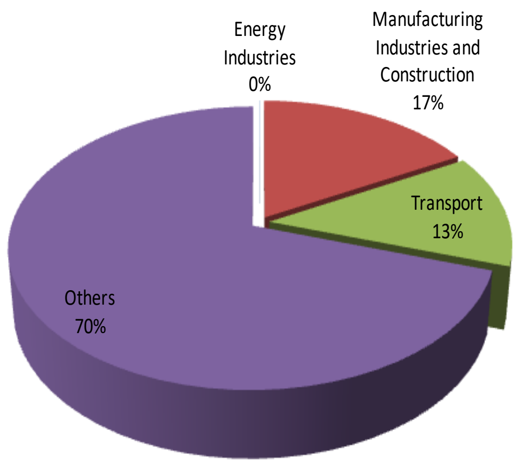

Figure 12: GHG emissions (CO2 eq in Gg) by various energy sectors

*(**Source:** Nepal's Third National Communication to the UNFCCC, 2021)*

3.2.2 Industrial Processes and Product Use (IPPU)

These processes involve chemical or physical transformation of raw materials into intermediate or final products. GHG emission from industrial processes is shown in Table 8 and a total of 368.4 Gg of CO_2 equivalent is estimated to have been emitted in the base year 2011. Emissions under the IPPU sector is largely contributed by cement production accounting for 92.2 percent of all emissions from the sector. The GHG emissions and precursor emissions are reasonably within the expected values. Since cement production is the major category, the NEEP (2012) dataset, with its detailed survey of all the limestone-based cement industries, was chosen to estimate the base year emissions. Similar to the previous National Communication reports of Nepal, the cement production is the most dominant category in IPPU sector for GHG emissions in Nepal with 92 percent contribution to the total GHG emissions of IPPU sector which is also not a different case for the emission inventory in the base year.

Table 8: Greenhouse gas emissions from the IPPU sector in base year 2011

Category	CO_2 (Gg)	N_2O (Gg)	HFC (kg)				CO_2-equivalent (Gg)
			R134a	R404a	R407a	R410a	
Cement production	350.2						350.2
Iron and steel production							
Product uses as substitutes for ozone depleting substances			7475.2	218	565	5085	13.0
N_2O from product uses		0.0035					0.0
Non-energy products from fuels and solvent use	5.2						5.2
Total	**355.4**	**0.0035**	**7475.2**	**218.0**	**565.0**	**5085.0**	**368.4**

*(**Source:** Nepal's Third National Communication to the UNFCCC, 2021)*

3.2.3 Agriculture, Forestry, and Other Land Use (AFOLU)

The GHG emissions and sinks were computed for the base year 2011 from official national activity data applying standard methodologies developed by Intergovernmental Panel on Climate Change (IPCC) to ensure consistency with the GHG inventory processes established under the UNFCCC convention. Direct GHGs (CO_2, CH_4, N_2O) and indirect GHGs (CO and NOx) were estimated in this sector. The computation shows that AFOLU sector resulted a net emission of 12121.33 Gg CO_2-eq yr^{-1} in 2011 (Table 9).

Table 9: Greenhouse gas emissions and removal (Gg) from the AFOLU sector in 2011

Activities	CO_2	CH_4	N_2O	CO_2-Eq
TOTAL AFOLU	**-16231.43**	**882.36**	**21.12**	**12121.33**
Livestock (3A)		**705.49**	**0.09**	**17664.07**
Enteric fermentation (3A1)		648.74		16218.50
Manure management (3A2)		56.75	0.09	1446.63
Land(3B)	**-17042.42**			**-17042.42**
Forest land (3B1)	-17077.81			-17077.81
Non-forest land	35.39			35.39
Aggregate sources and non-CO_2 emissions sources on land (3C)	**810.99**	**176.87**	**21.03**	**11499.65**
Biomass burning (3C1)	*229.85*	*17.88*	*0.62*	*860.25*
Forest	229.85	12.19	0.47	673.51
Crop residue		5.61	0.15	183.55
Grassland burning		0.08	0.00	3.20
Liming (3C2)	564.11			564.11
Urea application (3C3)	17.04			17.04
Direct N_2O emissions from managed soils (3C4)			0.86	255.12
Indirect N_2O emissions from managed soils (3C5)			0.23	67.93
Indirect N_2O emissions from manure management (3C6)			19.33	5760.30
Rice cultivations (3C7)		159.00		3974.91

*(**Source:** Nepal's Third National Communication to the UNFCCC, 2021)*

As can be seen in the Table 9, the livestock (3A) sub-category contributed an emission of 17664.07 Gg CO_2-eq yr^{-1}, an increase of emission by 43.5 percent (from 12308 Gg CO_2-eq yr^{-1}), from 2001 to 2011, Aggregated sources and non-CO_2 emission sources on land (3C) contributed 11499.65 Gg CO_2-eq yr^{-1}, while the Land (3B) subcategory acted as the net sink 17042.42 Gg CO_2-eq yr^{-1} due to sink of CO_2 in forestland and cropland.

3.2.4 Waste

Total methane emission in 2011 was 22.354 Gg, out of which wastewater handling was the biggest contributor followed by Solid Waste Disposal. Open burning contributes very small part of GHG emission (Table 10). Methane emission from solid waste is predominantly from urban areas whereas emission from wastewater handling is from the entire country. Government's plan to promote generation of biogas from solid waste and enforcing healthcare establishments to manage their own waste is likely to alter GHG emission contribution in future due to establishment of Incineration plant and Anaerobic Waste Treatment plants. Wastewater Treatment and Discharge contributes 70percent of total GHG Emission while solid waste disposal contributes 28 percent of total GHG Emission (equivalent CO_2). The emission from Waste Water Treatment and Discharge is significantly high because of presence of N_2O in wastewater handling.

Table 10: GHG Emission from different Waste Categories, 2011

Categories	Emissions [Gg]			Emissions [Gg; CO_2-Eq]			Total
	CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**	**CO_2-Eq**
Solid Waste Disposal		10.4633			261.5813		261.5813
Biological Treatment of Solid Waste		0.1047	0.0063		2.6171	1.8718	4.4889
Open Burning of Waste	2.3617	0.3402	0.0061	2.3617	8.5057	1.8250	12.6924
Wastewater Treatment and Discharge		**11.4461**	**1.2036**		**286.1522**	**358.6615**	**644.8137**
Domestic Wastewater		6.9628	1.2036		174.0689	358.6615	532.7304
Industrial Wastewater		4.4833			112.0833		**112.0833**
Total	**2.3617**	**22.3543**	**1.2160**	**2.3617**	**558.8563**	**362.3583**	**923.5860**

(Source: Nepal's Third National Communication to the UNFCCC, 2021)

3.3 Process, Criteria and Result of Sector Selection

In accordance with the *Handbook on conducting technology needs assessment for climate change* by the UNFCCC and the United Nations Development Programme (UNDP), published in November 2010, sector prioritization process and criteria for subsequent assessment of mitigation technology were carried out. Sectors identified for mitigation were based on their shares in national GHG emissions, their potential for feasible GHG mitigation options, their capacity to employ low-carbon technologies, and their contribution to overall national development goals.

Based on the national development strategies, poverty reduction strategies, sector policies and national programs like Initial National Communication and National Adaptation Programs of Action, national development priorities were identified jointly by TNA team of mitigation and adaptation technologies. A list of development priorities was clustered under the broad category of social, economic and environmental priorities based on the above mentioned national documents. These development priorities focused on the sustainable development whilst focus was essentially on short and long term scale to guide the overall process of technology needs assessment. The long list of development priorities was discussed thoroughly among the experts of TNA team and concluded with the final list (Table 11) which complies with changing climate.

Table 11: Prioritization criteria for selecting sectors for TNA

Prioritization Criteria	Description
Economic	
Balance of Payment	Reduction in the use of foreign exchange through reduced usage of imported goods
Income generation	Economic development and stability through inclusion of new job opportunities
Low-carbon economic development	Enhancement of productivity and improvement of livelihoods while adopting low-carbon emissions socio-economic development path
Improved mobility	Reduces travel time and thus improves work efficiency
Social	
Improved nutrition	Leads to the healthy living of the society
Increased food security	Improves access to food
Rural development	Leads to overall development of the nation
Energy security	Increases access to the energy
Environmental	
Reduced air and water pollution	Improves air and water quality
Reduced forests and soil degradation	Protects biodiversity and soil from degradation and thus improves the quality of natural resources

The method of giving points to sectors was designed. Based on the data of GHG inventory and sectors contribution to the development priorities, stakeholders were asked to score the sectors on a scale of 0-5.

0 – no benefit
1 – Faintly desirable
2 – Fairly desirable
3 – Moderately desirable
4 – Very desirable
5 – Extremely desirable

After all reviews and opinions were collected from experts/stakeholders, the priority points were summed for each sector as shown in Table 12.

Table 12: Performance matrix of prioritizing sector for mitigation

Sector	Economic Priorities	Social Priorities	Environmental Priorities	GHG reduction potential	Total benefit
Energy	5	5	4	3	17
Industrial Processes	3	4	3	2	12
Agriculture	5	5	3	4	17
Land use change and forestry	3	5	4	5	17
Waste Handling	2	3	3	2	10

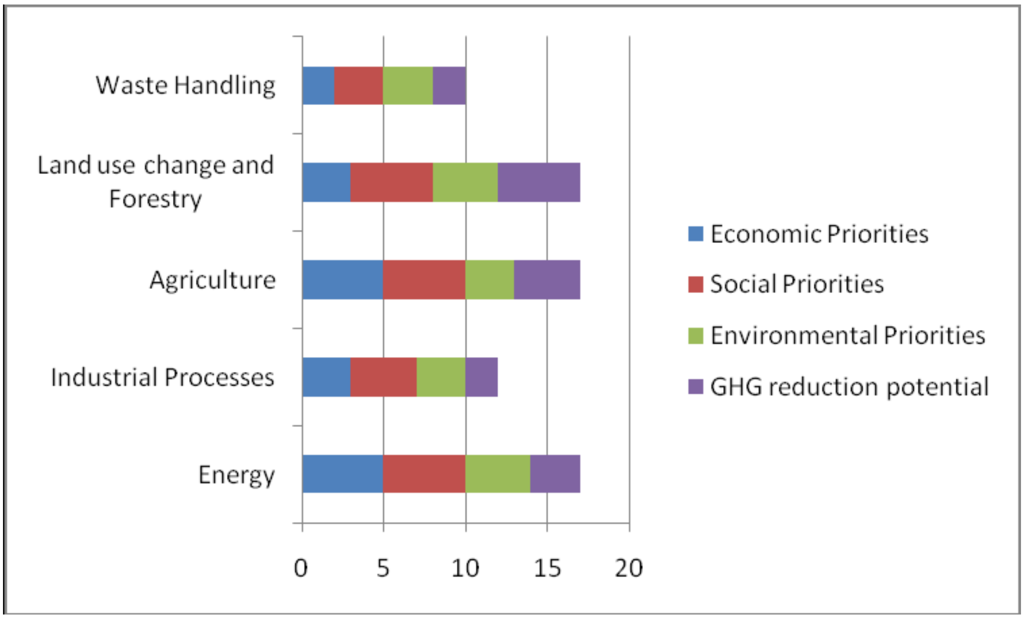

Figure 13: Criteria Contribution Graph

Thus obtained performance matrix was converted into criteria contribution graph based on the scoring for the sectors under different criteria as shown in Fig 13. On the basis of the criteria contribution graph, sectors have been judged on whether they are desirable for intervention. The sector having strong contribution to both GHG emission reduction and meeting development priorities have been considered as the priority sectors – in this case, the Energy sector, Agriculture sector, and Land use change and Forestry sector.

According to the National GHG Inventory for the base year 2011, others sub-sectors comprising of "*Commercial/Institutional, Residential, Agricultural*" energy consumption and transport sub-sector, and enteric fermentation and rice cultivation under agriculture sector were one of the major emitters of GHGs and hence with wider acceptance of the stakeholders, these sub-sectors were identified and prioritized. In the context of forestry sector, the decision was made to divide the sector under two headings; viz. forest protection and sink enhancement. Table 13 illustrates the desirability of the subsectors under the prioritized sectors.

Table 13: Identified of interventions in the selected sub-sectors

Sector/Sub-Sector	Development Priorities	GHG emission reduction
Energy		
Residential	Very desirable	Very desirable
Transport	Extremely desirable	Extremely desirable
Agriculture		
Enteric Fermentation	Very desirable	Extremely desirable
Rice Cultivation	Extremely desirable	Very desirable
Forestry		
Forest Protection	Extremely desirable	Extremely desirable
Sink Enhancement	Very desirable	Extremely desirable

CHAPTER-4: TECHNOLOGY PRIORITIZATION FOR ENERGY SECTOR

4.1 GHG Emissions and Existing Technologies

The general trend of GHG emission in energy sector shows increasing trends between the years 1994 and 2011 (Table 14). Contribution of the energy sector in total national emissions rose from 8.4 percent in 1994 to 27.8 percent in 2000 and 52.37 percent in 2011 as per the GHG inventory prepared for the initial, first and second national communications respectively. These increments are attributable to the increase in the economic activities leading to increased energy consumption.

Table 14: GHG Emission trend during 1994, 2000 and 2011

Sectors	INC, 1994 (CO2 eq Gg)		SNC, 2000 (CO2eq Gg)		TNC, 2011 (CO2eq Gg)	
	Total emission	% of total emission	Total emission	% of total Emission	Total emission	% of total emission
Energy	3266	8.4	6827	27.8	14751.66	52.37

Table 15 presents the main existing and possible technologies for the energy.

Table 15: Existing and possible technologies in energy sector

Residential Sub-sector	Transport Sub-Sector
I. Energy Efficiency a. Improved cooking stove (mud, metallic) b. Metallic stove (with Space Heating) c. Metallic stove (without space Heating) d. Energy efficient appliances e. Use of white LED for lighting **II. Renewable energy** a. Electric stoves b. Solar water heating c. Biogas for cooking d. Briquette e. Induction cooker/ Hot plate cooker f. Solar PV for lighting	a. Porter System b. Primitive Railways c. Aviation d. Electric Motor Bike e. Bus Rapid Transit System f. Electric car g. Bicycle h. Electric train i. Use of bio-diesel

4.2 An overview of technology in the energy sector and their mitigation benefits

A. Sub-sector: Residential

I. Improved Cook Stove (Mud and Metallic)

Improved Cook Stove (ICS) is a modified version of the traditional cooking stove. ICS is one of the simplest, inexpensive technologies and easy to build locally. ICS is designed to improve combustion efficiency of biomass as well as reduce exposure to indoor air pollution by introducing chimney to it. ICS can be used for cooking meals, boiling water and for cooking cattle food mostly in rural areas. Government of Nepal had targeted to maximize adoption of ICS in rural areas in order to make smoke free kitchen by 2017 (MoPE, 2017). The Biomass Energy Strategy (2017) sets goal to provide clean cooking technologies of at least tier-3 to all households by 2030.

GHG Mitigation Potential

Improved cook stove has thermal efficiency more than 15 percent compared to traditional stove or tripod whose thermal efficiency is less than 10 percent. Use of ICS not only reduces the firewood consumption but it can replace the kerosene stove that uses fossil fuel causing GHG emissions. Thus sustainable use of biomass in ICS has GHG mitigation potential.

II. Biogas technology

A biogas plant is an anaerobic digester that produces biogas from animal wastes or vegetable waste. Biogas is a type of biofuel created via anaerobic, or oxygen-free, digestion of organic matters by bacteria. A biogas plant is composed of a digester and a gas holder. Usually the digester is fed with animal dungs. It is increasingly popular in rural areas where it substitutes traditional cook stoves by providing clean energy for cooking.

GHG Mitigation Potential

Depending on capacity, one biogas plant has potential to reduce emission equivalent to 5 to 10.4 tCO_2 per year (MoE, 2011).

III. Electric cook stove

Electric cook stove is comparatively new in Nepal. It comprises of stove with a coil element, hot plate and induction cooker. With a coil element stove and hot plate they produce heat that gets transferred to the pot, pan, cooker etc. and then to the contents of those, with induction cooker it is the other way around. When cooking on an induction stove the pot or pan is the one generating the heat.

Induction cooking heats a cooking vessel with induction heating instead of heat transfer from electrical coils or a gas flame as with a traditional cook stove. For nearly all models of induction cooktop, a cooking vessel must be made of a ferromagnetic metal such as cast iron or stainless steel. Copper, glass and aluminum vessels can be placed on an interface disk which enables these materials to be used. In an induction cooker, a coil of copper wire is placed underneath the cooking pot. An alternating flows through the coil, which produces an oscillating magnetic field. This field induces an electric current in the pot. Current flowing in the metal pot produces resistive heating which heats the food. While the current is large, it is produced by a low voltage. With the recent increase in generation of hydro-electricity and the government encouraging the users to adopt electric cooking, electric cook stoves are likely to be the promising technology in the future.

GHG Mitigation Potential

This is the cleanest form of energy that is imperative in the current anthropogenic climate change as electric source do not emit any forms of GHGs. Besides it has potential to reduce the consumption of fuel woods as well as LPG in the residential sector for cooking. Since the grid emission factor is negligible in case of Nepal, complete replacement of the LPG by electric stoves have potential for 0.85 tons of CO_2 equivalent for each cylinder of LPG replaced.

IV. Solar water heater for space heating

Solar water-heaters for domestic use are low-temperature devices that heat water up to 65^{o}C. The average efficiency is 30 percent and it depends on the materials used to make the collectors, coils and insulators. Copper sheets and pipes, and good insulators like glass-wool and thermocol, can push efficiency up to 40 percent, while aluminium sheets and GI pipe can lower it to 20 percent.

GHG Mitigation Potential

Along with the flourish of tourism industry, the existing utilization of fuel wood for space heating has increased into greater folds and thus the consumption of fuel woods. Hence, solar technology has added value of being the clean energy with no addition of GHGs.

V. Bio-briquette for cooking and space heating

Biomass briquettes are a biofuel substitute to coal and charcoal. Biomass briquettes mostly made of green waste and other organic materials. These compressed compounds contain various organic materials, including rice husk, bagasse, ground nut shells, municipal solid waste, agricultural waste, or anything that contains high nitrogen content.

GHG Mitigation Potential

Biomass briquettes are emerging as the powerful substitute to the traditional fuel woods as these utilizes the green waste while at the same time, it also fulfills cooking and space heating purposes. Thus the human consumption of fuel wood is reduced and the green forest is saved from degradation, ultimately sequestration of GHGs.

B. Sub-sector: Transport

I. Porter System

Muscular power of carrying goods and human by other human represents porter system. The country like Nepal having different topography is most familiar with porter system and Nepal also has high potential of porter system.

GHG Mitigation Potential

Clean and healthier environment with zero carbon emission.

II. Primitive Railways
Diesel or coal run railways represent the primitive rail transport which is still used in Janakpur – Jayanagar route.

GHG Mitigation Potential
Less GHG is emitted in comparison to small sized vehicles.

III. Electric Motor Bike
Electric motorcycles and scooters are vehicles with two or three wheels that use electric motors to attain locomotion. Electric motorcycle, as distinguished from petro motorcycles and scooters, runs on battery charged by electricity.

GHG Mitigation Potential
Less pollution and environmentally friendly since it runs on electricity generated by hydropower.

IV. Bus Rapid Transit System
A bus rapid transit system (BRT) is a high-capacity transport system with its own right of way, which can be implemented against relatively low cost. It is a key technology in cities in developing countries, which can change the trend of modal shifts from more private vehicles towards public transportation, thereby bringing about a range of benefits, including reduced congestion, air pollution and greenhouse gases and better service to poor people.

GHG Mitigation Potential
One bus carries more than 60 passengers which would, otherwise have been done by many small vehicles. GHG emission is reduced significantly in comparison to small sized vehicles and motor cycles.

V. Electrical Car
Electric vehicles are about 2.5 times more energy efficient than their counterparts which are powered solely by internal combustion engines. This high energy efficiency is the main reason why electric vehicles can contribute to lower CO_2 emission and energy consumption of traffic substantially. However, the market share of electric vehicles is currently very small and confined mainly to urban transport.

GHG Mitigation Potential
Reduced diesel consumption and petrol consumption leads to reduction of greenhouse gases and air pollution.

VI. Bicycle
It is one of the cheapest and reliable means of transport system in both developing and developed countries. It is generally preferred for a cleaner environment.

GHG Mitigation Potential
Zero emission vehicles.

VII. Light Electric Train

Electric rail is a form of urban rail public transportation that generally has a lower capacity and lower speed than heavy rail and metro systems, but higher capacity and higher speed than traditional street-running tram systems. The term is typically used to refer to rail systems with rapid transit-style features that usually use electric rail cars operating mostly in private rights-of-way separated from other traffic but sometimes, if necessary, mixed with other traffic in city streets

GHG Mitigation Potential
Electric trains have zero tailpipe exhaust emissions if it runs on electricity generated from hydropower.

VIII. Biodiesel

Liquid bio fuels for transport, including biodiesel, have been in use (to a certain extent) for a very long time. In recent years however, they are promoted in both developed and developing countries as a result of the need to curb rising emissions from the transport sector, reduce dependence on expensive fossil oil imports and increase farm incomes.

GHG Mitigation Potential
Lesser GHG emission than the conventional diesel (up to 70% less).

Table 16 shows the summary of mitigation technologies, the status of the technologies for energy sector.

Table 16: Summary of mitigation technologies, the status of the technologies, and their descriptions for Energy sector

Technology for Climate Change Mitigation	**Status of Technology Availability & Accessibility A=Easy B=Medium C= Difficult**	**GHG emission reduction in 2030**	**Reduced air pollution**	**Improve Health Condition**	**Employment and new skill**	**Security of energy supply**	**Explanation**
Residential							
Improved Cook Stoves	A	X	X	X		X	Energy efficiency
Metallic stoves for cooking and space heating	A	X	X	X	X	X	Energy efficiency
Biogas for cooking	B	X	X	X		X	Utilization of by-products , alternative energy sources

Technology for Climate Change Mitigation	Status of Technology Availability & Accessibility A=Easy B=Medium C= Difficult	GHG emission reduction in 2030	Reduced air pollution	Improve Health Condition	Employment and new skill	Security of energy supply	Explanation
Electric cook stove	B	X	X	X			Renewable energy source
Solar water heating	B	X	X				Renewable energy source
Transport							
Bus Rapid Transit System	A	X	X			X	Bus Rapid Transit System helps in energy security of country by reducing fuel consumption
Electric Train	B		X	X	X		Employment opportunities and health improvement
Biodiesel	B	X			X	X	Helps in GHG reduction and energy security
Light Electric Train	B	X	X		X	X	Helps in overall GHG reduction through transport sectors
Electric Car	C	X	X		X		Helps in overall GHG reduction through urban transport sectors
Electric Motorbikes	C	X	X				Reduces pollution by replacing petrol motorbikes

4.3 Criteria and Process of Prioritization

A. Criteria of prioritization

The whole process of technology prioritization was driven based on the contribution of the technologies towards sustainable development goals and mitigation in light of climate change. A stakeholder's consultation workshop was held on Jan 4, 2013 to prioritize the mitigation technologies. Wider group of experts and stakeholders were involved in finalizing the criteria on which the assessments were based. The expert group agreed on the following set of criteria as shown in Table 17 for prioritizing mitigation technologies in energy sector:

Table 17: Criteria of technology prioritization in the Energy sector

SN	Criteria	Specification/Definition
1	Costs (C1)	This is the most important group of criteria in deciding which technology will be invested and how they are going to be invested to receive the desired results.
1.1	Capital cost	It is based on initial costs such as technology fees, facility building costs, and transfer fees to attain the technology.
1.2	Operation and Maintenance cost (C2)	It is based on other costs such as annual maintenance cost, technology operation cost, etc. Lower cost results in higher scores
1.3	Cost effectiveness for mitigation	It is based on cost estimation of the technology to reduce GHG emissions. Lower cost result in higher scores.
2	Environmental Benefits	To reduce GHG emissions, and improve environment the technology must generate environmental benefits.
2.1	GHG emission reductions in 2030 (C3)	This is a very important and crucial criterion of technology assessment to predict the future trends of climate change response technologies. Technologies with higher potential of GHG emission reduction will have higher scores.
2.2	Reduced air pollution (C4)	Improving air quality by reducing air pollutants such as SOx, NOx, non-methane volatile organic compounds, dust, fly ash and odour.
3	Social Benefits	These are the benefits from the technologies good enough in income generating activities.
3.1	Energy Efficiency (C5)	Increasing the energy efficiency by reducing energy losses in unnecessary activities and replacing inefficient devices.
3.2	Security of energy supply (C6)	Meeting the energy demand of the nation is the key requirement to fulfil the current situation of energy deficit.
4	Economic Benefits	The introduction of efficient technology will not only save the fuel but also provide new opportunity for income generating activities which will create more jobs and revenue.
4.1	Balance of Payment (BoP) (C7)	This criterion assesses the potential of the technology to contribute to reducing expenditures in foreign currencies, particularly through reducing material imports. This will contribute to the stable and sustainable development and reducing imports.
4.2	Employment and new skills (C8)	It is the potential of a technology to create work opportunities and reducing the rate of unemployment.

B. Process of prioritization

Technology Fact Sheets (TFS) for pre-selected technology were prepared by the mitigation team and shared with the stakeholders. The technologies were then scored on a scale of 0-100 by a stakeholder group, consisting of 15 experts. The experts were asked to give a score from 0-100 (0 means least preferable and 100 means best preferable option). The most and least preferred options were identified first and then scores were provided in between 100 and 0 to other options. The average value of scores has been taken into account in Table 18.

Table 18: Scoring results of technologies for energy sector

SN	Technologies	C1	C2	C3	C4	C5	C6	C7	C8
1	**Sub-sector: Residential**								
1.1	Metallic stoves for cooking and space heating	32	26	32	41	31	35	35	44
1.2	Biogas for cooking	63	69	63	63	63	59	50	44
1.3	Electric cook stove	53	52	40	53	59	53	47	41
1.4	Solar water heating	46	50	59	37	40	34	49	56
2	**Sub-sector: Transport**								
2.1	Bicycle	38	44	43	50	44	38	38	44
2.2	Electric Vehicles	43	41	56	50	43	63	47	41
2.3	Mass transport bus rapid transit system	66	63	47	46	61	50	62	62

This was followed by assessing weights for the criteria, to enable stakeholders to determine the relative importance of each criterion. The weighting was done after the scoring, as weights can only be given to criteria within the decision context. In assessing weights, there were different opinion of experts involved in analysis process. As a result of fruitful debates on the degree of importance of different criteria, weights for each criterion was provided. The weights were then normalized as below:

- Contribution to Capital costs priorities (CW1) – 10 percent
- Contribution to Operation & Maintenance cost priorities (CW2) – 5 percent
- Contribution to Energy Efficiency (CW3) -10 percent
- Contribution to GHG emission reduction in 2030 priorities (CW4) -15 percent
- Contribution to Reduced air pollution priorities (CW5) -20 percent
- Contribution to Balance of payments (CW6) -15 percent
- Contribution to Employment and new skills priorities (CW7) – 15 percent
- Contribution to Security of energy supply (CW8) – 10 percent

In each sector, overall weighted score was then calculated by combining the weights and scores of the most preferred technologies. Let the preference score for option *i* on criterion *j* be represented by s_{ij} and the weight for each criterion by w_j, then n criteria the overall score for each option, S_i, is given by:

$$S_i = w_1 s_{i1} + w_2 s_{i2} + \ldots + w_n s_{in} = \sum_{j=1}^{n} w_i s_{ij}$$

The formula and suffixes are adopted from the document provided by the UNEP Risoe Centre. The overall weighted scored for identified technologies in energy sector is presented in Table 19.

Table 19: Weighting results for technologies under energy sector

SN	Technologies	CW1 10%	CW2 5%	CW3 10%	CW4 15%	CW5 20%	CW6 15%	CW7 15%	CW8 10%	Overall results
1	**Sub-sector: Residential**									
1.1	Metallic stoves for cooking and space heating	3.2	1.3	3.2	6.15	6.2	5.25	5.25	4.4	34.95
1.2	Biogas for cooking	6.3	3.45	6.3	9.45	12.6	8.85	7.5	4.4	58.85
1.3	Electric cook stove	5.3	2.6	4.0	7.95	11.8	7.95	7.05	4.1	50.75
1.4	Solar water heating	4.6	2.5	5.9	5.55	8.0	5.1	7.35	5.6	44.60
2	**Sub-sector: Transport**									
2.1	Bicycle	3.8	2.2	4.3	7.5	8.8	5.7	5.7	4.4	42.40
2.2	Electric Vehicles	4.3	2.05	5.6	7.5	8.6	9.45	7.05	4.1	48.85
2.3	Mass transport bus rapid transit system	6.6	3.15	4.7	6.9	12.2	7.5	9.3	6.2	56.55

4.4 Result of Technology Prioritization

The stakeholder's Consultation Workshop on TNA Considering Adaptation Technologies and Mitigation Technologies" organized on January 4, 2013 finalized the prioritization of the technologies under two thematic sub-sectors namely residential and transport. The prioritized technologies are biogas and electric cook stoves under residential sub-sector, and rapid bus transit under transport sub-sector.

Lastly, sensitivity analysis was conducted to assess the robustness of the results relative to the weights and scores applied and other uncertainties. It showed that, for most measures, the experts' judgment did not vary significantly. The results and relevance of prioritized technologies are shown in Table 20 and 21 respectively.

Table 20: List of prioritized technology in the Energy sector

Availability/scale	Technology	Mitigation potential in 20 years (mil. tCO_2)	Benefit from MCDA assessment	Estimated investment cost USD in million
Long-term/small	Electric Cook Stove	316.3	39	963
Short-term/small	Biogas	54	43	111
Short-term/small	Bus Rapid Transit	2.41	42	100

Table 21: Relevance of the prioritized technologies to the existing policy and strategy

National policy/ strategy/policy study	Strategies and measures	Selected Technology	Policy Objectives
Biomass Energy Strategy, 2017	Measures to increase access to clean cooking technologies to all households.	Electric cook stoves	To enhance access and modernize biomass energy resources and at the same time reducing dependency over imported fossil fuels.
Rural Energy Policy, 2006	Specific working policies for development and promotion of various renewable energy technologies.	Biogas for cooking	To contribute to rural poverty reduction and environmental conservation by ensuring access to clean, reliable and appropriate energy in the rural areas.
Motor Vehicles and Transport Management Act, 1993	Large buses with carrying capacity more than 50 passengers	Bus Rapid Transit	To move towards mass transportation and for energy efficiency

CHAPTER-5: TECHNOLOGY PRIORITIZATION FOR FOREST SECTOR

5.1 GHG Emissions and Existing Technologies

There is a wide difference in the GHG emissions estimated in the three national communications Nepal has prepared. In the Initial National Communication (INC), total emission from the LULUCF sector was estimated to be 22895 Gg CO_2 equivalent which reduced to 16909 Gg CO_2 equivalent in Second National Communication (SNC). During this period total removals from the same sector increased by more than two folds i.e. -29684 Gg CO_2 equivalent. The GHG inventory carried out in initial and second national communications were based on "*1996 IPCC guidelines for National GHG inventory*". For the purpose of third national communications, the "*2006 IPCC guidelines for National GHG inventory*" was adopted which has change in emission sectors. LULUCF and Agriculture sector were combined into the AFOLU sector. Therefore, the estimates present is TNC is not directly comparable to the emission estimates available in INC and SNC. The total emissions from the AFOLU sector was 29199.14 Gg CO_2 equivalent while the removal was 17077.81 Gg CO_2 equivalent.

Table 22: Emission from LULUCF/AFOLU sector in the year 1994 and 2011

Sectors	INC, 1994 (CO_2 e Gg)		SNC, 2000 (CO_2 e Gg)		TNC, 2011 (CO_2 e Gg)	
	Total emission	Total Removal	Total emission	Total Removal	Total emission	Total Removal
LULUCF	22,895	-14,778	16,909	-29,684		
AFOLU					29,199.14	-17,077.81

Table 23 presents the main existing and possible technologies in the AFOLU sector.

Table 23: Existing and possible technologies in AFOLU sector

Forest Protection and Management	Sink Enhancement
a. Forest Protection b. Improvement of harvesting techniques c. Improvements in the product conversion and utilization efficiency	a. Analog forest b. Reforestation c. Afforestation d. Agro forestry e. Urban forest f. REDD

5.2 An Overview of Possible Mitigation Technology in the Forest Sector and their Mitigation Benefits

A. Forest Protection and Management

1. Forest Protection

Technology description:

It is an effort to reduce the destruction or conversion of forest to other non-forest uses. For example, move from shifting to permanent intensive agriculture/pasture. This requires investment in the necessary infrastructure and extension services necessary to convert shifting farmers/ranchers into sedentary land users. This option should be examined in the context of the respective country's rural development goals and policies. Another example is supplementary economic activities for shifting farmers. This may boost their earnings and as such reduce their demand on forest land for subsistence. Measures which increase the opportunities for harvesting and marketing of non-timber forest products such as nuts, honey and fiber should be encouraged. Also, introducing small-scale rural industries such as carpentry, brick making, weaving etc. may curtail the rate of deforestation associated with subsistence farming. This option cannot be treated in isolation from the country's rural development plans. However, within the development context, such an option should be very attractive.

GHG Mitigation Potential:

This option is a good long-term mitigation option to reduce emissions from land use changes that involve shifting to agriculture or pasture. It has mitigation potential of 55-220 tC/ha.

2. Silviculture

Technology description:

Silviculture systems could be broadly divided into two systems, i.e. selection system (polycyclic) and shelter wood systems (monocyclic). The Selection System aims to keep all-aged stands through timber cuttings at shorter intervals. Many light cuttings are made. Seedlings will become established in small gaps. Under this system, two or more intensive harvests are possible during one rotation. The selective felling of exploitable trees is done over an area at periodic intervals. The shelter wood system is introduced usually when it became necessary to harvest more intensively and regeneration is not assured under the selection system. Basically, the shelter wood system attempts to produce a uniform crop of trees from young regeneration through both heavy harvesting and broad Silviculture treatments. A new even-aged tree is established by applying preparatory and establishment cuttings to natural regeneration (i.e. seedlings and saplings) of the desired trees. At an appropriate time, the remaining over-storey is removed.

GHG Mitigation Potential:

It has mitigation potential of 49 tC/ha.

3. Improvements in the product conversion and utilization efficiency

Technology description:

Improvements in the product conversion and utilization efficiency can reduce emissions significantly. This involves technological intervention and tend to find wide applicability in a region of which forest industries are dominated by mills which have a conversion efficiency of less than 25 percent in pit sawing and about 40 percent in conventional sawmills. Improving various operational aspects of machinery and equipment in the wood industries may boost the amount of biomass converted to wood products by a significant proportion. Replacing the old generation mills in the sector by a newer vintage can easily double the conversion efficiency. Installing capacities for residue utilization for bio-fuels and tertiary products also maximizes useful biomass utilization and reduces emissions.

GHG Mitigation Potential

The mitigation benefit would be reduced usage of the wood products as the by-products will be utilized to fulfill the demand.

B. Sink enhancement

1. Analog Forest

Enhanced Natural Regeneration (ENR)

Analog forests attempt to reverse the loss of forest cover by planting trees and lesser plants on deforested lands, regenerating the structure and functions of original forests. This is also commonly called as enhance regeneration or enrichment planting.

GHG Mitigation Potential

It has mitigation potential up to 50-170 tC/ha.

2. Reforestation

Planting trees on degraded land in forest area.

GHG Mitigation Potential

Reforestation-short has mitigation potential up to 55tC/ha and reforestation-long has up to 155tC/ha.

3. Timber Plantation

Short-rotation Forestry

Short-rotation forestry is defined as a practice under which high-density, sustainable plantations of fast-growing tree species producing woody biomass on agricultural land or on fertile but degraded forest land. Trees are grown either as single stems or as coppice systems, with a rotation period of less than 30 years and with an annual woody production of at least 10 Tonnes of dry matter or 25 m^3 per hectare. The practice helps to optimize the use of natural resources. The biomass produced can be used for construction, pulp and paper, fodder and energy. Wood from short-rotation forestry may replace wood from natural and protected forest areas and thus help conserve valuable natural forests for future generations.

In SRF, Eucalyptus, Sissau (*Dalbergia sissoo*) and Kadam (*Anthocephalus indicus*) could be selected for Tarai districts while *Populus* spp. and *Salix* spp. could be planted in mid-hills and mountain regions. As agriculture cultivation are decreasing in private land, private sector can be motivated towards timber plantation with appropriate incentives.

GHG Mitigation Potential

It has mitigation potential up to 34-150tC/ha.

3. Agro-forestry

Improving carbon sequestration and storage in both soil and biomass through planting trees intercropped with annual crops for the purpose of producing both agriculture and forest products or planting trees following contour for wind and soil protection, as well as for providing agriculture and wood products. Long rotation systems that use trees for windbreaks, border planting and over-storey shade can sequester carbon for many decades.

GHG Mitigation Potential

It has mitigation potential up to 94tC/ha.

4. Urban Forestry

Tree planting activities include parks and gardens, green belts, residential shade trees, and road side and demarcation trees in the rural areas. Urban tree planting offers advantages of reducing greenhouse gas by sequestering carbon, and reducing energy consumption for air conditioning. At high latitude countries, urban tree planting provides shelter that reduces heating system emissions in winter. Based on the study done by USDA Forest service and Houston Green, the use of tree cover could reduce the use of energy by 16percent or avoid the loss of USD 55 million.

GHG Mitigation Potential

It has mitigation potential up to about 300tC/ha.

Table 24 presents the summary of mitigation technologies, the status of the technologies for forestry sector.

Table 24: Summary of mitigation technologies, the status of the technologies, and their descriptions for Forestry sector

Technology for Climate Change Mitigation	Status of Technology Availability & Accessibility A=Easy B=Medium C= Difficult	Reducing GHG emission	Increasing carbon sequestratio	C-Substitution	Maintaining or increasing forest
Forest Protection and management					
Forest protection	A	X	X		X
Silviculture	B	X			X
Improvements in the production conversion and utilization efficiency	C	X			
Sink Enhancement					
Analog Forest(Enhanced Natural Regeneration)	A		X		X
Reforestation	B	X	X		X
Afforestation	B		X		
Short Rotation forestry	B		X		X
Agroforestry	C	X			X
Urban Forest	C		X		

5.3 Criteria and Process of Technology Prioritization

A. Criteria of Prioritization

The forestry expert group agreed on following set of criteria as shown in Table 25 for prioritizing mitigation technologies in forest sector:

Table 25: Criteria of technology prioritization in the forestry sector

SN	Criteria	Specification/Definition
1	Costs	This is the most important group of criteria in deciding which technology will be invested and how they are going to be invested to receive the desired results.
1.1	Capital cost (C1)	It is based on initial costs such as technology fees, facility building costs, transfer fees, etc. to attain the technology. Less capital intensive technologies are preferred most.
1.2	Operation and Maintenance cost (C2)	It is based on other costs such as annual maintenance cost, technology operation cost, etc. Lower cost results in higher scores
1.3	Cost effectiveness for mitigation (C3)	It is based on cost estimation of the technology to reduce GHG emissions. Lower cost result in higher scores
2	Environmental Benefits	To reduce GHG emissions, adapt to climate change and improve environment, the technology must generate environmental benefits.
2.1	GHG emission reductions in 2030 (C4)	This is a very important and crucial criterion of technology assessment to predict the future trends of climate change response technologies. Technologies with higher potential of GHG emission reduction will have higher scores.

SN	Criteria	Specification/Definition
2.2	Improving and preventing soil degradation (C5)	The criterion is based on soil prevention potential through reducing release of solid waste to the environment and soil quality improvement
2.3	Protecting water resources and reducing flow depletion (C6)	This assesses the potential of water use efficiency enhancement in production, waste water reduction, and contribution to the protection of surface and groundwater resources
3	Social Benefits	These are the benefits from the technologies good enough in economic and social terms in a long run
3.1	Job opportunity (C7)	It is the potential of a technology to create work opportunities and reducing the joblessness rate. This criterion is used to assess the overall societal objectives.
3.2	Rural Development(C8)	The criterion assesses the contribution of the technology to economic upliftment resulting into overall rural development.
4	Economic Benefits	Technology needs assessment must look at the economic aspect because the purpose of technology innovation is to create more economic benefits, or more specifically, more revenue. At the same time, development of a new technology should satisfy the overall objective, that is, to ensure development of all three aspects: economic, social and environmental
4.1	Livelihood Improvement(C9)	This criterion assesses the contribution of the technology to the economic stability and development through activities such as developing new industries, creating investment environment, building and maintaining infrastructure, reducing costs and opening more opportunities for business, etc. which in the long run contribute to the improved livelihood.
4.2	Balance of Payment (BoP) (C10)	This criterion assesses the potential of the technology to contribute to reducing expenditures in foreign currencies, particularly through reducing material imports. This will contribute to the stable and sustainable economic development and reducing imports.

B. Process of prioritization

Technology Fact Sheets (TFSs) for pre-selected technologies were prepared by the mitigation team and shared with the stakeholders. These TFSs enabled stakeholder groups to prioritize technologies. The technologies were then scored on a scale of 0-100 by a stakeholder group, consisting of 15 experts. The average value of scores has been taken into account (Table 26).

Table 26: Weighting results for technologies under forestry sector

SN	Technologies	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
1	**Sub-sector: Sink Enhancement**										
1.1	Enhanced Natural Regeneration (ENR)	44	50	38	44	44	33	33	28	33	28
1.2	Short rotation forestry	61	50	44	33	47	39	56	56	61	72
1.3	Agro-forestry	38	44	50	56	44	67	53	58	47	42
2	**Sub-sector: Forest Protection and Management**										
2.1	Silviculture	78	44	56	44	44	56	56	44	78	56
2.2	Forest Protection	22	56	44	56	56	44	44	56	22	44

The normalized weights of the criterion have been provided as following:

- Contribution to Capital cost priorities (CW1)-10 percent
- Contribution to O&M cost priorities (CW2)-5 percent
- Contribution to Cost effectiveness for mitigation priorities (CW3)-10 percent
- Contribution to GHG emission reductions in 2030 priorities (CW4)-15 percent
- Contribution to Improving and preventing soil degradation priorities (CW5)- 10 percent
- Contribution to Protecting water resources and reducing flow depletion priorities (CW6)-10 percent
- Contribution to Job opportunity priorities (CW7) -15 percent
- Contribution to Rural development priorities (CW8) -10 percent
- Contribution to Livelihood improvement priorities (CW9)-10 percent
- Contribution to Balance of payment priorities (CW10))- 5 percent

In each sector, technologies were scored and weighted for each criterion and arranged in priority order (Table 27). The more the point was, the higher was the rank.

Table 27: Weighting results for technologies under forestry sector

SN	Technologies	CW1 10%	CW2 5%	CW3 10%	CW4 15%	CW5 10%	CW6 10%	CW7 15%	CW8 10%	CW9 10%	CW10 5%	Overall weighted score
1	**Sub-sector: Sink Enhancement**											
1.1	Enhanced Natural Regeneration (ENR)	4	3	4	7	4	3	5	3	3	1	37
1.2	Short rotation forestry	6	3	4	5	5	4	8	6	6	4	51
1.3	Agro-forestry	4	2	5	8	4	7	8	6	3	2	49
2	**Sub-sector: Forest Protection and Management**											
2.1	Silviculture	8	2	6	7	4	6	8	4	8	3	56
2.2	Forest Protection	2	3	4	8	6	4	7	6	2	2	44

5.4 Result of Technology Prioritization

The stakeholder's workshop organized on 4th January 2013 finalized the prioritization of technologies under two thematic sub-sectors namely sink enhancement and forest protection and management. The prioritized technologies are short rotation forestry and silviculture.

Lastly, sensitivity analysis was conducted to assess the robustness of the results relative to the weights and scores applied and other uncertainties. Analysis provided by experts proved that the priority measures for each selected sub-sector are priority measures according to all the experts. Analysis showed that, for most measures, the experts' judgment did not vary significantly. The result and relevance of prioritized technology are shown in Table 28 and 29 respectively.

Table 28: List of prioritized technology in the Forestry sector

Availability/ scale	Technology	Mitigation potential in 20 years (mil. tCO_2)	Benefit output from MCDA	Estimated abatement cost in USD/tCO_2 e
Short-term/ medium scale	Silviculture	804	40	7
Short-term/ medium scale	Short rotation forestry	592	38	5

Table 29: Relevance of the prioritized technologies to the existing policy and strategy

National policy/ strategy/policy study	Strategies and measures	Selected Technology	Policy Objectives
- National Forest Policy, 2019	Adopts policy of sustainable forest management enhance productivity of the forest area and production of forest based products.	- Silviculture	- Maintaining carbon stock for future
- Forestry Sector Strategy, 2016-2025	- Increase the forest area being managed in sustainable and productive manner. - Improve the harvesting technology for forest products and promote 'green' products - Establish forest carbon trade or payment mechanisms by linking forests, biodiversity and watershed conservation and management	- Short rotation forestry	- Increasing carbon sequestration - Maintaining carbon stock

CHAPTER-6: TECHNOLOGY PRIORITIZATION FOR AGRICULTURE SECTOR

6.1 GHG Emissions and Existing Technologies

There is a wide difference in the GHG emissions estimated in the three national communications Nepal has prepared. In the initial national communications, total emission from the Agriculture sector was estimated to be 27197 Gg CO_2 equivalent which reduced to 16916 Gg CO_2 equivalent in second national communications. The GHG inventory carried out in initial and second national communications were based on "*1996 IPCC guidelines for National GHG inventory*". For the purpose of third national communications, the "*2006 IPCC guidelines for National GHG inventory*" was adopted which had change in emission sectors. LULUCF and Agriculture sector were combined into the AFOLU sector. Therefore, the estimates present is TNC is not directly comparable to the emission estimates available in INC and SNC. The net emissions from the AFOLU sector was 12121.33 Gg CO_2 equivalent which makes 43.03 percent of the total GHG emission for base year 2011.

Table 30: Emission from Agriculture/AFOLU sector in the year 1994 and 2011

Sectors	INC, 1994 (CO_2 e Gg)		SNC, 2000 (CO_2 e Gg)		TNC, 2011 (CO_2 e Gg)	
	Total emission	% of total emission	Total emission	% of total emission	Total emission	% of total emission
Agriculture	27197	92.6	16916	68.9		
AFOLU					12121.33	43.03

6.2 An Overview of Possible Mitigation Technologies in the Agriculture Sector and their Mitigation Benefits

A. Livestock Management

1. Use of Local Crop Residue (LCR) for feeding ruminants

Use of crop residues of locally available plant materials as feed is an age old practice in Nepal. However, in recent years many farmers burn the residue due to problem in field preparation for the next crop and shrinking of common land thereby leading to deficit of local grasses. In this scenario, efficient use of crop residues may be the viable option for boosting the livestock production. The problem is use of dry straw and grasses increases the emission of methane from ruminant animals. If such feeding materials are treated with ammonia or alkali, these feeds can be made not only nutritious and digestible but also they reduce the amount of methane emitted. This may bring about economic and social co-benefits, particularly for the rural poor (Uprety, 2064). The main barriers to the adoption of this technology are the technical knowhow for the farmers and extension of the technique.

GHG Mitigation Potential

Methane emissions of ruminant animals are produced through the normal fermentation of the feed taken by animals in the digestive tract. The energy loss in the form of methane by ruminant animal accounts for about 2 percent-15 percent of the total energy intake (IPCC, 2000). Generally, the amount of methane emissions by a single animal increases with the weight of the animal. Higher level methane emissions are observed under greater feed intake and lower feed digestibility. Therefore, the improvement of feed quality and animal productivity is an effective approach to reduce methane emissions of ruminant animals (Mathison, et al., 1998).

2. Urea Molasses Multi-Nutrient Block (UMMB)

UMMB is a special preparation (15 part urea, 28 part molasses, 40 part bran, 1 part salt and 4 part lime) made into blocks of two kg weight. This type of block, upon feeding, has been proven to increase the milk production and reduce methane emission. This is a cost-effective feeding strategy and is being used by the farmers in Chitwan and Nawalparasi districts. Recently National Agriculture Research Centre (NARC) has developed the equipment to produce UMMB and is being distributed to the district Livestock offices and NARC stations. This may bring about economic and social co-benefits, particularly for the rural poor (Uprety, 2064,). The main barriers are unavailability of the raw materials, time-taking preparation process, and limited extension service for this technology followed by desired with appropriate modification according to the location in terms of its ingredients.

GHG Mitigation Potential

It has mitigation potential up to 14kg/head/yr along with increase in feed conversion efficiency, 25 percent increase in milk yield, CH_4 reduction by 27 percent and 60 percent increase in animal productivity.

B. Rice Cultivation

1. Alternate Wetting and Drying (AWD) in rice cultivation

Water management is one of the most confounding factors affecting methane emission. The average emission in saturated soil was found to be 0.3 to 0.6 kg/ha/day while in intermittent wetting and drying it was 0.1 to 0.4 kg. Intermittent irrigation is an option for minimizing CH_4 emission. Increasing water percolation would add oxygen-rich water to the reduced soil layer and decrease methane production (Vivekanandan and Jayasankar, 2008).

GHG Mitigation Potential

AWD technology can reduce the number of irrigations significantly compared to farmer's practice, thereby lowering irrigation water consumption by 25 percent, reducing diesel fuel consumption for pumping water by 30 liters per hectare, and producing 500kg more rice grain yield per hectare. The visible success of AWD has dispelled the concept of yield losses under moisture stress condition in non-flooded rice fields. Adoption of AWD technology reduced water use and methane emissions, and it increased rice productivity. It can reduce methane emissions by 50 percent as compared to rice produced under continuous flooding.

2. Direct Seeding in Rice Cultivation (DSR)

Methane emission occurs as a result of anaerobic decomposition of organic matters in flooded rice fields. This gas escapes to the atmosphere primarily by diffusive transport through the rice plants during the growing season (UNDP and MoE, 2003). The practice of direct seeding alone accounts for a reduction effect of 16-22percent in the seasonal methane emissions as compared with the practice of transplanting. In direct-seeded rice, flooding periods are shorter and cultural disturbance of reduced soils is minimized (Vivekanandan and Jayasankar, 2008) and so is the methane emission. Substantial saving in labor requirements make this type of crop establishment economically viable, although yields are lower (Wassmann et al., 2000). Therefore, this technology is getting popularity in the world because of cost effectiveness and environmentally safety. The main barriers are low germination, lack of suitable varieties and locally adoptable technology, and heavy weed infestation.

GHG Mitigation Potential

According to Wassmann and Pathak (2007), costs of emissions saving through direct seeding was found to be more than US$35 per tCO_2e saved. This technology is a feasible alternative to conventional practice with good potential to save water, reduce labour requirement, mitigate green-house gas (GHG) emission and to adapt to climate risks.

3. Nitrification inhibitor-Nimin

Nitrification inhibitors are known to inhibit methane oxidation (Bronson and Mosier, 1994). Lindau et al. (1993) reported that some nitrification inhibitors can mitigate methane emissions from rice fields as well. They are, therefore, dual-purpose technologies for both N_2O and CH_4 mitigation. The use of the nitrification inhibitors such as Nimin or placement of urea super-granule in flooded rice fields can be considered as suitable options for mitigation of methane emissions from rice fields without affecting grain yields where flood waters are deep (30cm) but not shallow (5cm). These measures not only improve N-use efficiency in lowland rice cultivation but also reduce methane emissions from deep-flooded rice fields.

GHG Mitigation Potential

It provides control practices for mitigating CH_4 emissions from rice cultivation.

Table 31 shows the summary of mitigation technologies, the status of the technologies for agriculture sector.

Table 31: Summary of mitigation technologies, the status of the technologies, and their descriptions for Agriculture sector

Technology for Climate Change Mitigation	Status of Technology Availability & Accessibility A=Easy B=Medium C= Difficult	Contribution to GHG mitigation	Ease of application	Utilization of local resources	Improvement in the productivity
Livestock Management					
Use of Local Crop Residue for feeding ruminants (LCR)	A		X	X	
Urea Molasses Multi-nutrient Block (UMMB)	B	X	X	X	X
Rice Cultivation					
Alternate Wetting and Drying in rice cultivation (AWD)	B	X	X	X	X
Direct Seeding in Rice Cultivation (DSR)	A	X	X		X
Nitrification inhibitor-Nimin	C	X	X		X

6.3 Criteria and Process of Technology Prioritization

The agricultural expert group agreed on set of criteria as given in Table 32 for prioritizing mitigation technologies in agriculture sector.

Table 32: Criteria of technology prioritization in the agriculture sector

SN	Criteria	Specification/Definition
1	Costs	This is the most important group of criteria in deciding which technology will be invested and how they are going to be invested to receive the desired results.
1.1	Capital cost (C1)	It is based on initial costs such as technology fees, facility building costs, transfer fees, etc. to attain the technology. Less capital intensive technologies are preferred most.
1.2	Operation and Maintenance cost (C2)	It is based on other costs such as annual maintenance cost, technology operation cost, etc. Lower cost results in higher scores
1.3	Cost effectiveness for mitigation (C3)	It is based on cost estimation of the technology to reduce GHG emissions. Lower cost result in higher scores
2	Environmental Benefits	To reduce GHG emissions, adapt to climate change and improve environment, the technology must generate environmental benefits.
2.1	GHG emission reductions in 2030 (C4)	This is a very important and crucial criterion of technology assessment to predict the future trends of climate change response technologies. Technologies with higher potential of GHG emission reduction will have higher scores.

SN	Criteria	Specification/Definition
2.2	Air quality (C5)	The criterion is based on soil prevention potential through reducing release of solid waste to the environment and soil quality improvement.
2.3	Wise use of water	This assesses the potential of water use efficiency enhancement in production, waste water reduction, and contribution to the protection of surface and groundwater resources
3	Social Benefits	These are the benefits from the technologies good enough in economic and social terms in a long run
3.1	Poverty Alleviation (C6)	Based on the potential to meet the food demand and the goal of improving life quality and finances of people in rural areas. Technologies with higher potential has higher score
3.2	Job Opportunity (C7)	Benefits from a good technology to the society are shown in its potential to create work opportunity reducing the joblessness rate. This criterion is used to assess the overall societal objectives.
4	Economic Benefits	Technology needs assessment must look at the economic aspect because the purpose of technology innovation is to create more economic benefits, or more specifically, more revenue. At the same time, development of a new technology should satisfy the overall objective, that is, to ensure development of all three aspects: economic, social and environmental
4.1	Economic Development (C8)	This criterion assesses the contribution of the technology to the economic stability and development through activities such as developing new industries, creating investment environment, building and maintaining infrastructure, reducing costs and opening more opportunities for business, etc.
4.2	Balance of Payment (BoP) (C9)	This criterion assesses the potential of the technology to contribute to reducing expenditures in foreign currencies, particularly through reducing material imports. This will contribute to the stable and sustainable economic development and reducing imports.

Technology Fact Sheets (TFSs) for pre-selected technologies were prepared by the mitigation team and shared with the stakeholders. These TFSs enabled stakeholder groups to prioritize technologies. The technologies were then scored on a scale of 0-100 by a stakeholder group, consisting of 15 experts. The average value of scores has been taken into account and presented in Table 33:

Table 33: Weighting results for technologies under Agriculture sector

Technologies	C1	C2	C3	C4	C5	C6	C7	C8	C9
Sub-sector: Livestock management									
Use of Local Crop Residue (LCR) for feeding ruminants	0	67	33	17	50	17	100	33	50
Urea Molasses Mineral Block (UMMB)	100	33	67	83	50	83	0	67	50
Sub-sector: Rice cultivation									
Alternative Drying and Wetting (AWD) in rice cultivation	83	50	50	50	33	50	67	100	50
Direct Seeding in Rice cultivation	17	50	50	50	67	50	33	0	50

As a result of fruitful debates on the degree of importance of different criteria, normalized weights for each criterion have been provided as following:

- Contribution to Capital cost priorities (CW1)-10 percent
- Contribution to O&M cost priorities (CW2)-5 percent
- Contribution to Cost effectiveness for mitigation priorities (CW3) -10 percent
- Contribution to GHG emission reductions in 2030 priorities (CW4)-25 percent
- Contribution to Reduced air pollution priorities (CW5)- 10 percent
- Contribution to poverty alleviation (CW6) -15 percent
- Contribution to Efficient use of human resources priorities (CW7) -10 percent
- Contribution to Economic development (CW8) -5 percent
- Contribution to Balance of payment (CW9)-10 percent

In each sector, technologies were scored and weighted for each criterion and arranged in priority order (Table 34). The more the point was, the higher was the rank.

Table 34: Weighting results for technologies under agriculture sector

Technologies	CW1 10%	CW2 5%	CW3 10%	CW4 25%	CW5 10%	CW6 15%	CW7 5%	CW8 10%	CW9 10%	Overall weighted score
Sub-sector: Livestock management										
Use of Local Crop Residue (LCR) for feeding ruminants	0	3	3	4	5	3	5	3	5	31
Urea Molasses Mineral Block (UMMB)	10	2	7	21	5	13	0	7	5	70
Sub-sector: Rice cultivation										
Alternative Drying and Wetting (AWD) in rice cultivation	8	3	5	13	3	8	3	10	5	58
Direct Seeding in Rice cultivation	2	3	5	13	7	8	2	0	5	45

6.4 Result of Technology Prioritization

The stakeholder's workshop organized on January 4, 2013 finalized the prioritization of the technologies under two thematic sub-sectors namely livestock management and rice cultivation. The prioritized technologies are urea molasses mineral block (UMMB) and alternate wetting and drying (AWD).

Lastly, sensitivity analysis was conducted on assessment results to assess the robustness of the results relative to the weights and scores applied and other uncertainties. Analysis provided by experts proved that the priority measures for each selected sub-sector are priority measures according to all the experts. Analysis showed that, for most measures, the experts' judgment did not vary significantly. The result and relevance of prioritized technology are shown in Table 35 and 36 respectively.

Table 35: List of prioritized technology in the Agriculture sector

Availability/ scale	Technology	Mitigation potential	Benefit output from MCDA	Estimated abatement cost in USD
Short-term/ small scale	Urea Molasses Multi-Nutrient Block(UMMB)	14(kg/head/yr)	57	43.8($/head/yr)
Short-term/ small scale	Alternate Wetting and Drying in rice cultivation (AWD)	11.67 tCO_2/yr	42	7.378($/$tCO_2$)

Table 36: Relevance of the prioritized technologies to the existing policies of agriculture sector

National policy/ strategy/policy study	Strategies and measures	Selected Technology	Policy Objectives
Agriculture Development Strategy (2015-2035)	Development of overall economy by commercialization of agriculture	Urea Molasses Multi-Nutrient Block (UMMB)	- To contribute in GHG mitigation - Improvement in productivity
National Agricultural Policy, 2004	The bases of a commercial and competitive farming system shall be developed and made competitive in the regional and world Markets.	Alternate Wetting and Drying in rice cultivation (AWD)	- To contribute in GHG mitigation - Utilization of Local resources - Improvement in productivity

CHAPTER-7: SUMMARY AND CONCLUSION

Under the framework of Technology Needs Assessment-mitigation technologies, priority sectors/sub-sectors were identified and relevant technologies were prioritized. The list of prioritized technologies that have potential to mitigate climate change is summarized in Table 37.

Table 37: List of prioritized technologies to mitigate climate change

SN	Sector/Technology	Availability/Scale
1.	Energy Sector	
	Electric Cook Stove	Long term/small-scale
	Biogas	Short term/medium-scale
	Bus Rapid Transit	Short term/medium-scale
2.	Agriculture Sector	
	Urea Molasses Block	Short term/large-scale
	Alternate Wetting and Drying	Short term/small-scale
3.	Forest Sector	
	Silviculture	Short term/medium-scale
	Short rotation forestry	Short term/medium-scale

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Annex 1: Technological Fact Sheets for selected technologies

1. Technologies Fact Sheet for Electric Stoves

Sector	Energy
Sub-Sector	Residential
Scale	Small-Scale
Availability	Available
Technology to be included in prioritization?	Yes
Technology Name	Electric Stove
Subsector GHG emission	42.72 Million t CO2 from residential sector in 2010
Background/Notes, Short description of the technology option sourced from ClimateTechWiki, Seminars, etc.	With a coil element stove they produce the heat that gets transferred to the pot, pan, cooker etc. Electric stoves have efficiency around 70percent. This high energy efficiency is the main reason why electric cook stoves can contribute to lower the CO2 emission and energy consumption. However, the market shares of electric stoves are currently still small and are mainly intended for urban people. Purchase cost and operating cost are slightly high for rural people; however, it is affordable to urban people. (source: climatetechwiki.org)
Implementation assumptions, How the technology will be implemented and diffused across the subsector?	The stoves are easily available in the market at reasonable price for urban people. The electricity required for its operation is made available to the users.
Reduction in GHG emissions	69.3 million tons carbon dioxide equivalent by 2030
Impact Statements - How this option impacts the country development priorities	
Country social development priorities	It is reliable, safe and affordable as well. The improved health is the major social benefit.
Country economic development priorities	Dependency on imported fuel for cooking is reduced and shift to electricity from hydropower in the country. The cost of electricity is less compared to LPG and kerosene used for cooking. The time saved during cooking can be further utilized by households in other activities.
Country environmental development priorities	Reduced air pollution: Electricity derived from hydropower does not emit any air pollution while in use. Biodiversity: the dependency on fuel wood reduces thereby contributing to reduce forest degradation.
Other considerations and priorities such as market potential	It is user friendly and spare parts are easily available in the market.
Costs	
Capital costs (in million USD)	$ 970
Operational and Maintenance costs	2 percent of capital cost
Cost of GHG reduction (in million USD)	$ 485

Note: All numbers in this Technology Fact Sheet are estimates and approximations and, therefore, best treated as illustrative.

2. Technologies Fact Sheet for Electric Stoves

Sector	**Energy**
Sub-Sector	Residential
Scale	Small-Scale
Availability	Available
Technology to be included in prioritization?	Yes
Technology Name	Biogas for cooking
Subsector GHG emission	42.72 Million t CO2 from residential sector in 2010
Background/Notes, Short description of the technology option sourced from ClimateTechWiki, Seminars, etc.	A biogas plant is an anaerobic digester that produces biogas from animal wastes or energy crops. Biogas is a biofuel created via anaerobic digestion of organic matter by methanogenic bacteria in absence of Oxygen. A biogas plant is composed of a digester and a gas holder or dome. It is preferred to fossil fuels, or other solid biomass based fuels. It is possible to improve the quality of biogas by enriching its methane content. Use of biogas can reduce the number of trees that are being felled. (source: climatetechwiki.org)
Implementation assumptions, How the technology will be implemented and diffused across the subsector?	Gobar Gas Company-2047 model is the major plant being promoted in Nepal. Government, non-government and number of private agencies are working for its implementation. Biogas is basically preferred in tarai and hilly region.
Reduction in GHG emissions	54 Million t CO2 equivalents by 2030.
Impact Statements - How this option impacts the country development priorities	
Country social development priorities	Smoke-free kitchen, so women and children are no longer prone to respiratory infections. Women are spared the burden of gathering firewood.
Country economic development priorities	Buying fossil fuel resources (e.g. kerosene, LPG, charcoal or fuel wood) is reduced. Switch from traditional biomass resources or fossil fuels to biogas fired generation capacity improves security of energy supply (locally as well as nationally or regionally) as the feedstock can mostly be acquired locally.
Country environmental development priorities	Keeping manure and waste in a confined area and processing them in the digester reduces amount of pollutants in the immediate environment and improve sanitation. Households no longer need to extract wood for cooking, which can reduce deforestation where people heavily rely on fuelwood. The sludge remaining after digestion is a good fertilizer that contributes to increase in land productivity. The release of methane is avoided thus contributing to climate mitigation.
Other considerations and priorities such as market potential	Spare parts are easily available in the market.
Costs	
Capital costs (in million USD)	$ 111
Operational and Maintenance costs	2 percent of capital cost
Cost of GHG reduction (in million USD)	$ 378

Note: All numbers in this Technology Fact Sheet are estimates and approximations and, therefore, best treated as illustrative.

3. Technologies Fact Sheet for Bus Rapid Transit systems

Sector	Energy supply and consumption (excl. industry)
Sub-Sector	Transport
Technology Name	Bus Rapid Transit systems
Scale	Small-Scale
Availability	Available
Technology to be included in prioritization?	Yes
Background/Notes, Short description of the technology option sourced from ClimateTechWiki, Seminars, etc.	A bus rapid transit system (BRT) is a high-capacity transport system with its own right of way, which can be implemented against relatively low cost. It is a key technology in cities in developing countries, which can change the trend of modal shifts from more private vehicles towards public transportation, thereby bringing about a range of benefits, including reduced congestion, air pollution and greenhouse gases and better service to poor people. Its main drawback compared to other urban transport systems is its demand for urban space. To be most effective, BRT systems (like other transport initiatives) should be part of a comprehensive strategy that includes increasing vehicle and fuel taxes, strict land-use controls, limits and higher fees on parking, and integrating transit systems into a broader package of mobility for all types of travellers. (Source: climatetechwiki.org)
Implementation assumptions, How the technology will be implemented and diffused across the subsector?	It is assumed that BRT will be implemented in inner ring-road of KTM valley, which is around approximately 27.3 Km and in 13 Km stretch of Suryabinayak to Maitighar. The transport demand in Kathmandu valley is expected to reach 35 million person-kilometres (pKm) in 2030. BRT will account for 15percent of total transport demand of Kathmandu valley, i.e. nearly 65 billion pKm. The total travel demand for 20 years has been projected around to be 432 billion pKm.
Reduction in GHG emissions over 20 years	2.41 Million t CO2 equivalent
Impact Statements - How this option impacts the country development priorities	
Country social development priorities	Reduced crash death and injuries. Social equity by providing affordable, high quality transports.
Country economic development priorities	As BRT is more energy efficient than conventional bus system, it can reduce, to some extent, foreign dependence on imported petroleum products. BRT system will help in improving speed of public transports, thus, resulting in improved mobility.
Country environmental development priorities	Reduced Air Pollution: With reduction in passenger cars, considerable reduction in air pollution can be expected. Reduced GHG emission.
Other considerations and priorities such as market potential	
Costs	
Capital costs (in million USD)	USD 2 million per Km
Operational and Maintenance costs	Operation costs are assumed to be 30percent of total capital costs per year.
Cost of GHG reduction (in million USD)	$ 378

4. Technologies Fact Sheet for Forestry (Short Rotation Forestry (SRF) Technology)

Sector	**Forestry**
Sub-Sector	Forest Protection and Management
Technology Name	Short Rotation Forestry (SRF) Technology
Scale	Small-Scale
Availability	Available
Technology to be included in prioritization?	Yes
Subsector GHG emission	The net emissions of CO_2 from AFOLU sector was about **12121.33** Gg.
Background/Notes, Short description of the technology option sourced from ClimateTechWiki, Seminars, etc.	Short Rotation Forestry (SRF) refers to the growing of trees (usually willow or poplar) in extremely dense stands, harvested at 3-4 years intervals and regenerated from the stools, which are expected to survive 5 rotations at least. As a rotation crop, SRF is harvested at specific intervals, to provide a regular and constantly renewable supply of fuel. The development of SRF for renewable energy production is a new sector with potential for considerable expansion, offering benefits for growers, developers, consumers, local communities and the environment. Local foresters, producers and communities including forest officers and concessionaries can play crucial role in wider adoption of the technology. However, limited scientific data on SRF technology is a barrier in application of technology. So far SRF technology is yet to be established in Nepal and further research is required. However several Asian countries are practicing the technology which has mitigation potential ranging from 33 tC/ha to 125 tC/ha.
Implementation assumptions, How the technology will be implemented and diffused across the subsector?	There is a challenge of proper implementation and making this technology popular among stakeholders that demands for productive multi-stakeholders participation and knowledge sharing and transfer about Short Rotation Forestry (SRF) technology and practices. However it is getting popular in some community forest and it is expected to reach in all forestry sector of Nepal as well.
Reduction in GHG emissions over 20 years	It has mitigation potential up to 34-150 tons of Carbon per hectare
Impact Statements - How this option impacts the country development priorities	
Country social development priorities	Forest being one of the most prominent sectors contributes valuable resources to the livelihood of huge number of people. The proposed technology helps to control the growth, composition, health and quality of forest to meet diverse needs and values maintaining continuous cover forestry in socially acceptable manner and thus secures social equity and can generate many opportunities to local people.
Country economic development priorities	There are many unproductive forest products which required appropriate management attention to render them productive from economic point of view. Similarly the proposed technology can generate employment opportunities and country also can access international funds in relations to CDM and REDD.
Country environmental development priorities	Since the technology can provide added benefits to the surrounding communities as it offers sustainable harvesting of

Sector	Forestry
	wood and thus reduce encroachment and maintain greenery thereby protecting the biodiversity. It adopts socially acceptable programs of forest protection, improving management of parks and protected areas, ensures satisfactory natural regeneration of harvested forests and forests damaged by fire, improves forest fire suppression and management capabilities and adopts reduced-impact logging practices.
Other considerations and priorities such as market potential	Forests plays crucial role in any initiative to combat climate change by altering, balancing and storing carbon flux. At the same time, balance can be created between enhancement and
Costs	
Capital costs (in million USD)	1,475,000 USD
Operational and Maintenance costs	Operation costs are assumed to be 5percent of total capital costs per year.
Cost of GHG reduction (in million USD)	The cost of GHG reduction is 5 USD/tCO2

5. Technologies Fact Sheet for Forest Protection and Management

Sector	**Forestry**
Sub-Sector	Forest Protection and Management
Technology Name	Silviculture
Scale	Small-Scale
Availability	Available
Technology to be included in prioritization?	Yes
Subsector GHG emission	The net emissions of CO_2 from land use change and forestry sector was about 8117 Gg.
Background/Notes, Short description of the technology option sourced from ClimateTechWiki, Seminars, etc.	Silviculture is a scientific practice of forest management by preventing forest from possible damage due to overcrowding, disease, exposure to wind and rain or competition for light and nutrients for maximum benefit. It helps to control the growth, composition, health and quality of forest to meet diverse needs and values maintaining continuous cover forestry. Silviculture systems could be broadly divided into two systems, i.e. selection system (polycyclic) and shelterwood systems (monocyclic). In selection systems, harvesting and regeneration are distributed throughout the forest rather than concentrated in specific areas; consequently, age or size classes are intimately mixed (Matthews, 1991, pp. 163 *et seq*.). In shelterwood systems, stands are regenerated under the shelter of the existing overstorey, which is gradually removed; the resulting regeneration is more or less even-aged depending on the exact configuration (Matthews, 1991, pp. 90)
Implementation assumptions, How the technology will be implemented and diffused across the subsector?	There is a challenge of proper implementation and making this technology popular among stakeholders which demands productive multi-stakeholders participation and knowledge sharing and transfer about siliviculture practices. However it is getting popular in some community forest and it is expected to reach in all forestry sector of Nepal as well.
Reduction in GHG emissions over 20 years	It has reduction potential of 49 tons of Carbon per hectare.
Impact Statements - How this option impacts the country development priorities	
Country social development priorities	Forest being one of the most prominent sectors contributes valuable resources to the livelihood of huge number of people. The proposed technology helps to control the growth, composition, health and quality of forest to meet diverse needs and values maintaining continuous cover forestry in socially acceptable manner and thus secures social equity and can generate many opportunities to local people.
Country economic development priorities	**Efficient use of Forest Resources** There are many unproductive forest areas that demands appropriate management attention to enhance productivity. The technology offers better forest management approaches which help to increase growth, composition and quality of forest to meet diverse needs of people in sustainable manner. **Benefits from Carbon Trading** The proposed technology can generate employment opportunities and country also can access international funds in relations to CDM and REDD.

Sector	Forestry
Country environmental development priorities	**Reduce Forest Degradation** Since it adopts socially acceptable programs of forest protection, improving management of parks and protected areas, ensures satisfactory natural regeneration of harvested forests and forests damaged by fire, improves forest fire suppression and management capabilities and adopts reduced-impact logging practices. **Biodiversity conservation** Since the technology can provide added benefits to the surrounding to surrounding communities as it offers the sustainable harvesting of wood and thus reduce the encroachment and greenery will be saved and thereby biodiversity
Other considerations and priorities such as market potential	Forests plays crucial role in any initiative to combat climate change by altering, balancing and storing carbon flux. At the same time, balance can be created between enhancement and conservation of forest carbon stocks, and exploration of economic opportunities to the local people.
Costs	
Capital costs (in million USD)	1,618,750 USD
Operational and Maintenance costs	Operation costs are assumed to be 5percent of total capital costs per year.
Cost of GHG reduction (in million USD)	The cost of GHG reduction is 7 USD/tCO2

6. Technologies Fact Sheet for Urea Molasses Mineral Block (UMMB)

Sector	Agriculture
Technology Name	Urea Molasses Mineral Block (UMMB)
Scale	Small-Scale
Availability	Available
Technology to be included in prioritization?	Yes
Subsector GHG emission	110.67 Million t CO2 from enteric fermentation (1994/95)
Background/Notes, Short description of the technology option sourced from ClimateTechWiki, Seminars, etc.	UMMB is a special preparation (15 part urea, 28 part molasses, 40 part bran, 1 part salt and 4 part lime) made into blocks of two kg weight. This type of block, upon feeding, has been proven to increase the milk production and reduce methane emission. This is a cost-effective feeding strategy and is being used by the farmers in Chitwan and Nawalparasi districts. Recently NARC has developed the equipment to produce UMMB and is being distributed to the Disrtict Livestock offices and NARC stations. This may bring about economic and social co-benefits, particularly for the rural poor (source: Uprety, C. R., 2064, Hamro Sampada, year 7, N0. 1 pp 102-103). The main barriers are the unavailability of the raw materials, time-taking preparation process, and limited extension services of this technology with appropriate modification according to the location in terms of its ingredients.
Implementation assumptions, How the technology will be implemented and diffused across the subsector?	There is a challenge of managing and making this technology popular among the farmers due to its infancy stage in Nepal and limited availability of required ingredients. However, it is getting popularity in accessible areas and is hoped to reach the remotes areas as well, especially in dairy farms. A set of supportive policies, programs and infrastructure is to be put in place, with the objective to shift 30percent of the total ruminants being served with UMMB feeding system in the country by 2020.
Reduction in GHG emissions	Increases feed conversion efficiency, increase in milk yield by 25 percent, CH_4 reduction by 27 percent, 60 percent increase in animal productivity is anticipated (UNDP, and MoE, Cambodia, 2003) and 2.98 million ton of CO_2 reduction is envisaged.
Impact Statements - How this option impacts the country development priorities	
Country social development priorities	**Improved nutrition:** The rural people who are not achieving the potential production of milk from the cows and buffalos will be benefitted by increased milk production which will improve the nutritional situation of the people. This is on line with the millennium development goal of alleviating hunger **Social cohesion:** Increased productivity of animals will attract more people towards animal farming which in turn will retain youth in the villages otherwise fleeing outside for better opportunities. Development of employment opportunities in the villages is one of the development priorities of the country.
Country economic development priorities	**Efficient use of animal resources:** There are many unproductive animals lacking appropriate feed to deliver the desirable limit of products in the country. With this technology, the milk production from livestock can be increased.

Sector	Agriculture
	Efficient use of human and capital resources: There is a big under or unemployment problems in rural areas. The proposed technology will generate employment opportunity in the villages promote efficient utilization of household members. The earned money will be reinvested in animal farming or used for other needful purposes.
Country environmental development priorities	**Reduced air pollution:** There is less emission of methane and consequently, reduced risk of climate change and .associated negative impacts to human **Biodiversity conservation:** Since there will be an efficient utilization of dry grasses and there will be less encroachment to the forest land for green fodder and greenery will be saved and thereby biodiversity.
Other considerations and priorities such as market potential	Milk has good market in the country but due to issues related to access, small size of the farmers, limited availability of collection and storage facilities and sometimes due to other social issues, the products cannot reach destination. Development of local market should therefore be preferential focus over transporting the products to a longer distance from origin. Hygiene and adulteration problems are also defaming the milk market.
Costs	
Capital costs (in million USD)	The production of UMMB costs about Rs.23-50 (Rs. 35 average) rupees each. To feed the 20percent of the present ruminant population (cattle: 7,199,260 + buffalo: 4,836,984 + (sheep: 801,371 + goat: 8,844,172)/2 = 21,681,787. If we take goat and sheep as half of the cattle and buffalo then the number becomes {7,199,260+4,836,984+ (80,1371 + 8,844,172)/2} = 27,699,909. One block will be for three days then the number of blocks for a year needed will be 27,699,909/3 = 9,233,303. On an average one block of 2 kg costs NRs. 35. The total cost will be 923,303*35 = NRs 323,165,605 which will be US$ 3,672,336/year
Operational and Maintenance costs	Operation costs are assumed to be 5percent of total capital costs per year.
Cost of GHG reduction (in million USD)	Annual capital cost of 3.7 Million USD plus O & M cost of 0.1 Million USD. Total cost for say year 2030 = 4 Million USD Mitigation achieved 110.67 million t CO2 Therefore cost of GHG reduction is 27 USD/ t CO2

7. Technologies Fact Sheet for Alternate Wetting and Drying (AWD)

Sector	**Agriculture**
Technology Name	Alternate Wetting and Drying (AWD)
Scale	Small-Scale
Availability	Available
Technology to be included in prioritization?	Yes
Subsector GHG emission	64.26 million t CO2 from rice cultivation (1994/95)
Background/Notes, Short description of the technology option sourced from ClimateTechWiki, Seminars, etc.	Water management is one of the most confounding factors affecting methane emission. The average emission in saturated soil was found to be 0.3 to 0.6 kg/ha/day while intermittent wetting and drying it was 0.1 to 0.4 kg. Intermittent irrigation is an option for minimizing CH_4 emission. Increasing water percolation would add oxygen-rich water to the reduced soil layer and decrease methane production (Vivekanandan and Jayasankar, 2008).
Implementation assumptions, How the technology will be implemented and diffused across the subsector?	There is a challenge of managing and making the technology popular among the farmers due to lack of controlled irrigation facilities and most of the rice growing areas are flooded during monsoon. It is possible to adopt this technology in the sloping flat lands of foot hills, river basins and hill terraces. A set of supportive policies, programs and infrastructure is to put in place, with the objective to shift 50percent of the total rice growing area in the country be shifted to the AWD by 2020.
Reduction in GHG emissions	11.67 tCO2/year
Impact Statements - How this option impacts the country development priorities	
Country social development priorities	**Improved nutrition:** The rice farmers who are not able to make good yield due to flooding and associated problems will be benefitted from the technology. If drained water is collected and stored in ponds, the same can be used in the time of water scarcity. **Social cohesion:** New technology will offer an opportunity for crop diversification thereby increase productivity which will attract more people to the farm. Increased farm productivity will help retain the youth in the villages otherwise fleeing out for better opportunities. Development of employment opportunities in the villages is one of the development priorities of the country.
Country economic development priorities	**Efficient use of land resources:** There are many farms with low land areas in Tarai and inner Tarai which are unproductive due to water logging which can be made productive if the technology is widely made available. **Efficient use of plant resources**: There are lot crops which can follow rice but could not be cultivated due water logging and wet soil. These crops can be cultivated and made the system more productive. This will diversify and increase the production of crops and food security will be ensured.
Country environmental development priorities	**Reduced air pollution:** There is less emission of methane and consequently, reduced risk of climate change and associated negative impacts on humane welfare **Biodiversity conservation:** Since there will be an efficient utilization of crop diversity and thereby conservation of agro-biodiversity will be enhanced.

Sector	Agriculture
Other considerations and priorities such as market potential	Diversified agro-products have good market but the concentration of the market in urban areas the farmers are not being reap the fruit of the market. Local market should be developed rather transporting the product far from the origin. Chemical poisoning of the products is being the matter of concern increasingly.
Costs	
Capital costs (in million USD)	Costs are incurred to build drainage canals in the farms and check dams to control the spillover of water from nearby rivers, which is not common. However, in potential areas it may be thought of for which on an average Rs. 50 thousand/ha in flood prone area of Tarai and inner Tarai is needed. 71percent of 1.5 million ha rice growing area is in this region which is about 1 million ha. Assuming that half of this area needs such treatment, the cost will be 500,000*50,000 = Rs 25,000,000,000. The structure will work for at least 20 years. So the annual cost will be Rs. 1,250,000,000
Operational and Maintenance costs	Operation costs are assumed to be 5percent of total capital costs per year. That is 1,250,000,000 * 0.05 = 62,500,000.
Cost of GHG reduction (in million USD)	Total annual cost in Nepali Rupees will be 1,250,000,000 +62,500,000 = 1,312,500,000. Annual capital cost Million USD plus O&M cost of 0.1 Million USD. Therefore cost of GHG reduction is 7.378 USD /tCO2

Bus Rapid Transit (BRT) Technology:

Among the technologies identified, Bus Rapid Transit System has been illustrated as the potential mitigation project idea based on the discussion with participants present for technology prioritization. Detail of BRT technology is presented below:

Brief summary

After the brief consultation with the sector experts and other stakeholders, it was agreed that Bus Rapid Transit (BRT) is the most promising mass transportation technology to mitigate the current level of GHG emissions and towards low carbon development. Furthermore, it has direct social impact as it reduces the resulting health effects and the traffic congestions in the roads.

It was suggested to consider BRT as project idea as a mitigation technology for the following routes in Kathmandu Valley:

1. BRT system along ring road, and
2. BRT system in Suryabinayak-Maitighar route.

Specific project ideas

The proposed project is for implementing two-way Bus Rapid Transit (BRT) transportation system with 24 buses along the ring road and 12 buses in Suryabinayak-Maitighar with mixed mode route for reducing GHG emissions in the transport sector.

Background

Transportation sector of Nepal is being met solely by imported petroleum products. With the exception of very few electric cars, the use of electricity in the transport sector is almost negligible. Being the second largest energy consuming sector, the energy consumption was about 20.8 million GJ in the year 2008/09. About 63% of the total petroleum was consumed in the sector. High Speed Diesel took the highest share with 67 % followed by Motor Spirit with about 20% and then Air Turbine Fuel with 12 %. LPG contributed about 1% of total energy requirement in transport sector. There were few electrical vehicles whose electrical consumption was very low.

A bus rapid transit system (BRT) is a high-capacity transport system with its own right of way, which can be implemented at reasonable cost. It is a key mass transit technology in cities in developed countries and it can change the trend of modal shifts from more private vehicles towards public transportation, thereby bringing about a range of benefits, including reduced congestion, air pollution and greenhouse gases, and better service to public. Its main drawback compared to other urban transport systems is its demand for dedicated road space.

BRT is actually the bus-way-system running in either separate dedicated lane or mixed mode as per road size to have less congestion on road through efficient mass transportation. BRT technology is very convincing technology for the country like Nepal as it reduces congestion on road, improves the Balance of Payment through decreased import of fossil fuels, and ultimately reduces GHG emission. BRT can either be bus running on diesel or other sources of fuel as per availability in the country but must have more than 50 number of passenger seat per bus.

The main goal of project is to develop mass transportation system in the Kathmandu valley by providing comfortable, affordable and efficient service to the city dwellers.

Project objectives:

- Increase awareness level of local passengers, local authorities, private sector and other relevant stakeholders on advantages of mass transportation system - BRT;
- Increase technical capacity of relevant stakeholders involved in technology application.

Project activities:

- Launch workshops and meetings for presentation of project goals and objectives;
- Organize round-table discussions with relevant stakeholders and various Transport Association;
- Launch campaigns to increase awareness level and to overcome social barriers;
- Conduct capacity building trainings for representatives of local authorities, private sector, NGOs, other relevant stakeholders and experts;
- Conduct specific trainings to increase technical capacity of local producers to improve the quality of produced BRTs;
- Implement pilot project, initially for one selected route only and then start similar project in the next route;
- Organize study committee to evaluate the project impact for the beneficiaries at local level for future deployment of this technology.
- Improve market linkages of target groups with relevant market players, including financial institutions, in order to create enabling framework for further application of the technology by local entrepreneurs.

Project outputs:

- Efficient running of BRTs in two routes of Kathmandu valley, 24 number of buses in ring road and 12 number of buses in Suryabinayak-Maitighar route;
- Reduction of approximately 2.41 million metric tons of GHG emission during the life time;
- At least 100 participants, including representatives of local authorities, private sector, local transport communities, NGOs, benefit with improved knowledge and capacity of economic and environmental advantages of BRT technology deployment;
- At least two financial institutions (government and private) and one local producer/importer are involved in the project;
- At least one national conference organized to disseminate project achievements at national level.

Project beneficiaries:

Project beneficiaries are the passengers travelling in daily route plus people walking along the road side every day. It is estimate that over 50000 passengers are benefited daily from introduction of this technology. Similarly, over 10000 people are benefited indirectly due to reduced emission.

Relevant stakeholders:

Ministry of Forests and Environment, Ministry of Finance, local governments, private sector, NGOs, city dwellers and the visitors are the major stakeholders of the project. The expected role and responsibilities of the stakeholders are as follows:

- Ministry of Finance will support implementation of the financial component of the project by ensuring hassle free to the financial resources required to pilot the project;
- Ministry of Forests and Environment will support project implementation by raising awareness of environmental importance of technology deployment;
- Ministry of Physical Infrastructure and Transport will lead the project implementation and support to overcome the institutional barriers;
- Private sector (financial institutions, producers/importers of BRTs) will be involved as market players actively participating in project implementation;

- NGOs will be involved in the project implementation cycle.

Project duration:
2 years

Project budget:
130 million USD

Project investment costs of efficient BRT in Kathmandu valley:
100 million USD

Operation and maintenance costs:
30 million USD

Project sustainability:
Project will lessen the pressure on imported fossil fuel and also help in providing the efficient transportation facility as mitigation technology for carbon emission reduction. Project will also help in reducing traffic congestion there by gaining appreciation from the general public. And this gesture is a positive impetus for the sustainability of the project.

Project deliverables:
Project is basically targeted to local people of Kathmandu valley to provide their daily movements at low cost along with reduction of carbon emission. The deliverables are the operating BRT system in the Kathmandu valley.

Project scope and possible implementation:
Projects will cover mainly two routes, one over ring road with 24 numbers of BRTs and second the Suryabinayak-Maitighar route with 12 numbers of BRTs.

Risks:
The main risks of project implementation are lack of knowledge regarding mass transportation system and demotivation of the investors due to slow return on investment.

Project monitoring and evaluation:
Project monitoring has to be done by selected committee formed by including government and non- government agencies. The committee must be autonomous to do its work for betterment of BRT facility in valley.

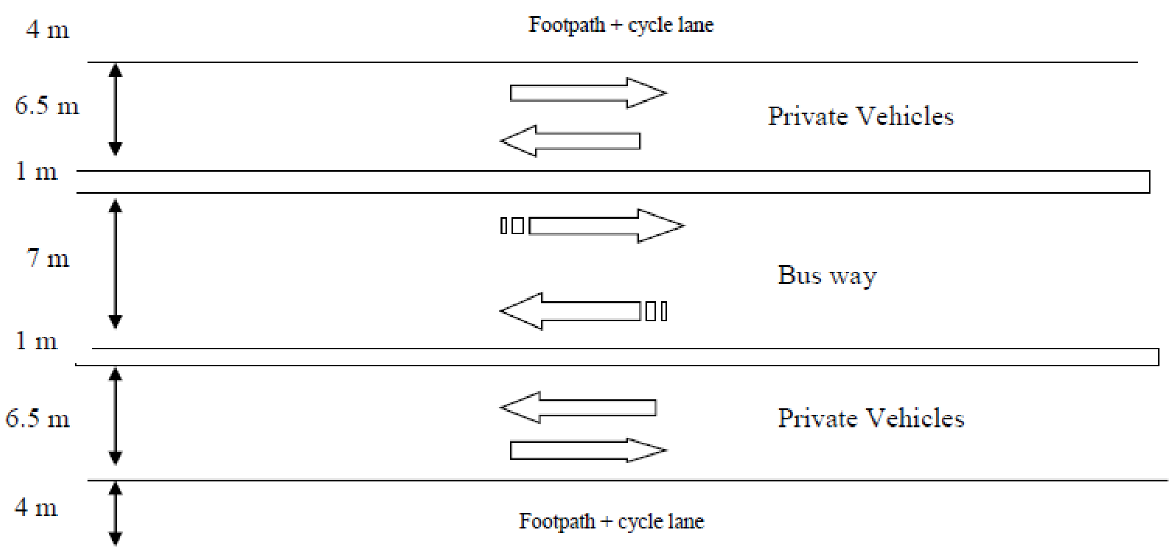

Figure: Mixed mode BRTs in 30 meter road for Maitighar-Suryabinayak route

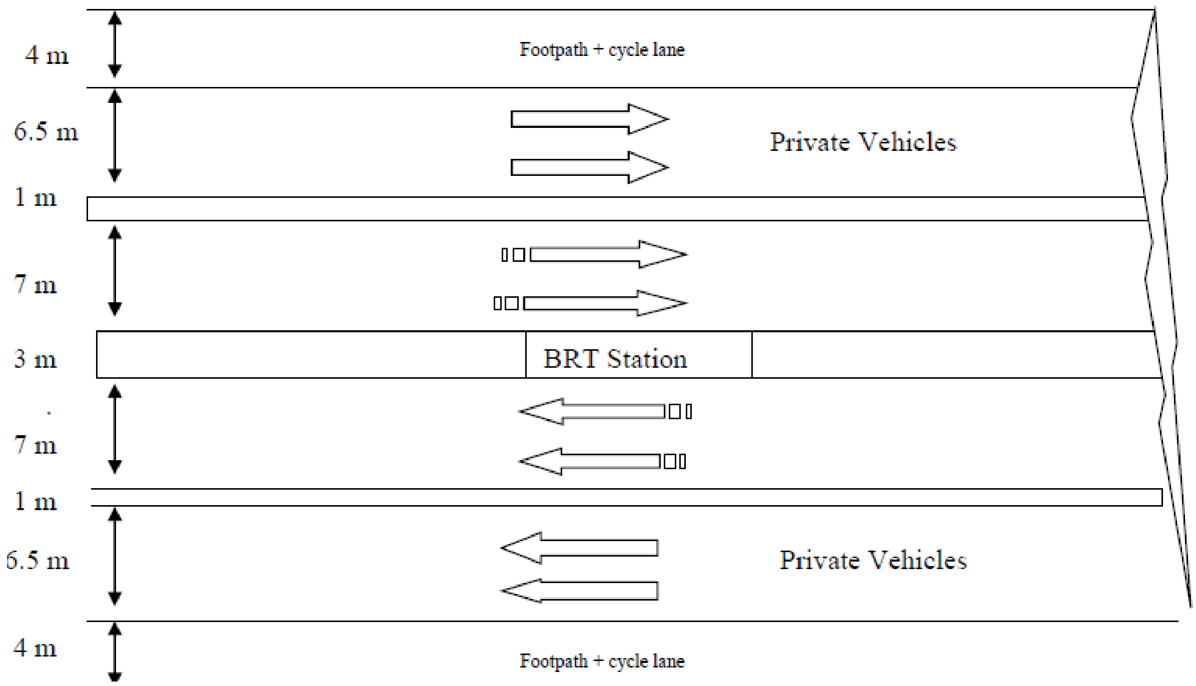

Figure: Two-way BRTs in 40 meter road for Ring Road route

Annex 2: List of Participants

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Annex 3: Photographs


TNA Considering Adaptation
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