NEPAL

THIRD NATIONAL COMMUNICATION TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE




GOVERNMENT OF NEPAL
MINISTRY OF FORESTS AND ENVIRONMENT

NEPAL'S THIRD NATIONAL COMMUNICATION TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

Government of Nepal
Ministry of Forests and Environment

June, 2021

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NEPAL'S THIRD NATIONAL COMMUNICATION TO THE UNFCCC

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Note: As per the decision of Government of Nepal on 18 May 2020, Nepal's political and administrative map has been updated. As the base reporting year for this TNC report was 2010/11, many of the study, analysis and information for this report were generated before the date of approval of updated political map. So, old political maps have been included in some of the places in this report.

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MESSAGE FROM THE SECRETARY

Climate change is now considered as one of the greatest challenges for the global community. The impacts of anthropogenic greenhouse gas (GHG) emission on the planet's climatic system has been very evident and one cannot deny the climate change now. Despite being a negligible contributor to the global GHG emission, Nepal is one of the most vulnerable countries in the world to the changing climate. Nepal has put in place an ambitious targets of emission mitigation through its Second Nationally Determined Contribution (NDC) which paves the pathways to low carbon emission development to reach the net zero emissions targets by 2050.

Being a least developed country, Nepal is trying very hard to balance between achieving sustainable development goals and climate actions. Insufficient technological, institutional and financial resources have been limiting factors for Nepal's climate actions.

Nepal is highly vulnerable to impacts of the climate change and extreme weather events due to its location in fragile mountainous ecosystems, limited resources and technology to adapt. Moreover, our economy is heavily reliant on climate sensitive sectors like agriculture, tourism and hydropower.

This Third National Communication (TNC) from Nepal to the United Nations Framework Convention on Climate Change (UNFCCC) elaborates the GHG inventory of reference year 2010/11, mitigation and adaptation actions taken and planned to be taken that are required to address adverse impacts of climate change.

On behalf of the Ministry of Forests and Environment (MoFE), I would like to extend my sincere appreciation to all the key stakeholders, relevant agencies, national experts and all individuals involved in the process of preparing this important document for their dedication and commitment. I would also like to thank our national and international partners including Global Environment Facility (GEF) and United Nations Environment Programme (UNEP) who had financially and technically supported Nepal for the development of this TNC document.

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FOREWORD

Nepal is committed to address the alarming impact of climate change and taking various initiatives that will eventually lead towards the path of climate resilience and sustainable development. Nepal has recently prepared and submitted its ambitious NDC paving the path to net zero emissions by mid-century. Recognizing adaptation as an emerging priority, Nepal has been implementing National Adaptation Programme of Action (NAPA) and Local Adaptation Plan of Action (LAPA) as strategic tools for internalizing appropriate adaptation measures in sectoral policies and programs.

Nepal has formulated Climate Change Policy in 2019 to contribute to socioeconomic prosperity of the nation by building a climate resilient society. As a party to the United Nations Framework Convention on Climate Change (UNFCCC), Nepal has been actively engaging in the international Climate Change regime. As a part of our commitment to the UNFCCC, Nepal has prepared the Third National Communication (TNC) report. This report gives an opportunity to share the climate relevant information with among countries and will help to mainstream climate change into national policies, plans and development.

This TNC report provides clear insight about Greenhouse Gas (GHG) inventory for base year 2010/11. It also highlights the vulnerability assessment in various sectors, adaptation options and mitigation potential for sustainable development. This report had demonstrated that the share of Nepal in global GHGs emission has increased from the previous National Communication. Considering this increment, Nepal has to adopt low greenhouse gas emission strategy in future.

The report has come to this stage with the support from various experts and agencies. In this regard, I would like to acknowledge Central Department of Environment Studies (CDES), Tribhuvan University, other involved consulting firms and individual consultants for their technical supports. Successful completion of this work would not have been possible without the technical support from United Nations Environment Programme (UNEP) and financial support from Global Environment Facility (GEF).

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Finally, I would like to thank all contributors who directly or indirectly involved during the whole process of preparing this report.

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ACRONYMS

ADB	Agricultural Development Bank
ADS	Agricultural Development Strategy
AEPC	Alternative Energy Promotion Centre
AFOLU	Agriculture, Forestry, and Other Land Use
ATF	Aviation Turbine Fuel
BAU	Business as Usual
BOD	Biological Oxygen Demand
CBS	Central Bureau of Statistics
CCA	Climate Change Adaptation
CCMD	Climate Change Management Division
CDES	Central Department of Environment al Science
CDIAC	Carbon dioxide Information Analysis Center
CDM	Clean Development Mechanism
CKD	Cement Kiln Dust
COD	Chemical Oxygen Demand
COP	Conference of the Parties
DCC	District Coordination Committee
DFRS	Department of Forest Research and Survey
DHM	Department of Hydrology and Meteorology
DNPWC	Department of National Parks and Wildlife Conservation
DOC	Degradable Organic Carbon
DoC	Department of Customs
DOF	Department of Forest
DoHS	Department of Health Services
DoI	Department of Industries
DoR	Department of Roads
DoTM	Department of Transport Management
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DWSS	Department of Water Supply and Sewerage
EbA	Ecosystem-based Adaptation
EDGAR	Emission Database for Global Atmospheric Research
EF	Emission Factor
EPCCMNC	Environmental Protection and Climate Change Management National Council
FAO	Food and Agriculture Organization
FCPF	Forest Carbon Partnership Facility
FOD	First Order Decay
FWS	Flood Warning System
FY	Fiscal Year
FYM	Farm Yard Manure

GDP	Gross Domestic Product
GESI	Gender Equity and Social Inclusion
GHG	Greenhouse Gas
GIZ	German Society for International Cooperation
GLOF	Glacial Lake Outburst Flood
GoN	Government of Nepal
GWP	Global Warming Potential
ICIMOD	International Centre for Integrated Mountain Development
ICS	Improved Cookstove
IMCCCC	Inter-Ministerial Climate Change Coordination Committee
INC	Initial National Communication
INGO	International Non-Governmental Organization
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Process and Product Use
ISW	Industrial Solid Waste
IUCN	International Union for Conservation of Nature
IWM	Improved Water Mill
LAPA	Local Adaptation Plan for Action
LPG	Liquefied petroleum gas
MoALD	Ministry of Agriculture and Livestock Development
MoCTCA	Ministry of Culture, Tourism and Civil Aviation
MoEWRI	Ministry of Energy, Water Resources and Irrigation
MoF	Ministry of Finance
MoFAGA	Ministry of Federal Affairs and General Administration
MoFE	Ministry of Forests and Environment
MOHA	Ministry of Home Affairs
MoUD	Ministry of Urban Development
MSW	Municipal Solid Waste
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NARC	National Agriculture and Research Council
NAST	Nepal Academy of Science and Technology
NCCSP	Nepal Climate Change Support Programme
NDC	Nationally Determined Contributions
NEA	Nepal Electricity Authority
NEEP	Nepal Energy Efficiency Programme
NGO	Non-Governmental Organization
NMVOC	Non-methane Volatile Organic Compound
NOC	Nepal Oil Corporation
NPC	National Planning Commission
ODS	Ozone Depleting Substance
PV	Photovoltaic
QA/QC	Quality Assurance and Quality Control

RCPs	Representative Concentration Pathways
REDD	Reducing Emissions from Deforestation and Forest Degradation
RET	Renewable Energy Technology
SAARC	South Asian Association for Regional Cooperation
SDG	Sustainable Development Goal
SNC	Second National Communication
TNC	Third National Communication
TWG	Thematic Working Group
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United States Geological Survey
VRA	Vulnerability and Risk Assessment
WASH	Water, Sanitation and Hygiene
WECS	Water and energy Commission Secretariat
WMO	World Meteorological Organization

Units of measurement

$	US Dollar
°C	degree Celsius
CO_2e	carbon dioxide equivalent
Gg	Gigagram
GJ	Giga joule
GWh	Giga watt hour
ha	hectare
hL	hectoliters
kg	kilogram
kl	kiloliter
km	kilometer
km^2	square kilometer
m	meter
m^3	cubic meter
masl	mean above sea level
mm	millimeter
MT	metric tonne
MW	mega watt
NPR	Nepali Rupee
yr	year

Chemical Compounds

CaO	Calcium oxide
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2-eq	Carbon dioxide equivalent
HFC	Hydrofluorocarbon
N_2O	Nitrous oxide
NMVOCs	Non-Methane Volatile Organic Compounds
NO_x	Oxides of Nitrogen
PFC	Perfluorocarbon
SF_6	Sulfur hexafluoride
SO_2	Sulfur dioxide

EXECUTIVE SUMMARY

This summary presents the major highlights of Nepal's Third National Communication (TNC) to the United Nations Framework Convention on Climate Change (UNFCCC). The TNC is the continuation of two previous communications– the Initial National Communication (INC) of 2004 and the Second National Communication (SNC) of 2014. It provides updated information on the country's national circumstances, greenhouse gas inventory, mitigation assessment, and vulnerability and adaptation assessment. It also presents other relevant information on Nepal's efforts towards achieving the objectives of UNFCCC.

A. National Circumstances

Nepal is located on the southern slopes of the Central Himalaya between 26°22' and 30°27' N latitudes and 80°04' and 88°12' E longitudes. Of its area of 147,181 sq. km, about 86% consists of mountains and hills, while the remaining has low-lying Terai plains. Within a short span of 145 km to 241 km, the altitude changes rapidly from 67m above mean sea level to 8848.86 m, giving rise to unique physiographic regions, climatic characteristics, biodiversity, ecosystem, agriculture or settlements. The country is divided into five physiographic regions: (1) Terai; (2) Siwalik (Churia); (3) Middle Mountains; (4) High Mountain; and (5) High Himal.

Nepal had a population of 26.5 million in 2011 census, with decreasing growth rate. It is a culturally diverse and rapidly urbanizing country. While there have been significant gains in many aspects of development in recent decades, around 19% of its population still lies below the poverty line and the economy is heavily dependent upon remittance from labor migration.

Nepal has been steadily reconstructing its infrastructures and economy that was devastated by the earthquake on April 2015. Most affected 32 district of the country is undergoing dedicated reconstruction programs for private housing, academic and heath infrastructures and archeological structures that were impacted by the earthquake through National Reconstruction Authority (NRA). During these six years, more than 90% of private housing, 83% of school buildings, 90% of government offices, 59% of health facilities and 54% of archeological and cultural buildings has been in the process of finalizing the construction (NRA, 2020). These reconstruction efforts have generated more than 4.5 million man-days of employment and subsequently healthy growth on GDP.

The country recently transitioned through the state restructuring process, brought about by the promulgation of new constitution in 2015. The centralized state is now divided into three tiers of governments, including the federal, provincial and local levels. Besides the federal government, it has seven provincial governments and 753 local governments. The local governments comprise six Metropolitan Cities, 11 Sub-metropolitan Cities, 276 Municipalities and 460 Rural Municipalities distributed in a total of 77 districts. While each tier has both shared and autonomous jurisdictions, a major departure is on entrusting local level governments with significant autonomous jurisdictions.

Climate change related policy effort has been going on in Nepal since the ratification of UNFCCC in early 1990s. Since the adoption of National Adaptation Programme of Action (NAPA) in 2010, the

integration of climate change adaptation into overall development and sectoral plans is being pursued. Environment Protection Act, 2019 and Regulations, 2020 are the overarching policy and legal instrument for climate change management of Nepal. Climate Change Policy, 2019 and Second Nationally Determined Contributions, 2020 are the leading guiding policy documents for Nepal's climate actions. Coordination mechanisms are established and adapted to the new institutional changes. The Ministry of Forests and Environment is working on further development of institutional mechanisms to be able to effectively work in new federal structure. It is also in the process of development of National Adaptation Plan for better integration of climate change in development planning and implementation.

B. National Greenhouse Gas Inventory

Nepal's Greenhouse Gas (GHG) inventory accounts their emissions by sources and their removals by sinks for the base year 2011. The inventory considers:

- Direct GHGs, which consist of Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur hexafluoride (SF6).
- Indirect GHGs, such as Carbon monoxide (CO), Nitrous oxides (NOx), Non-Methane Volatile Organic Compound (NMVOC), and Sulphur dioxide (SO_2).

The inventory was carried out in accordance with the 2006 IPCC Guidelines for reporting National Communications from Non-Annex 1 Parties and other relevant documents, using mainly Tier 1 approach, for lack of detailed disaggregated data for many activities in these four sectors. Also lacking in most activities was the national Emission Factor that is required in higher tier methods. The inventory accounted the emissions and removals from the following four sectors:

- **Energy;**
- **Industrial processes and product use (IPPU);**
- **Agriculture, forestry, and other land use (AFOLU); and**
- **Waste.**

While reporting the GHG inventory, this TNC presents a detailed account of its methodology, the quality assurance and quality control (QA/QC) measures, the results of the key source analysis, the quantification of the uncertainties associated with the estimates, and the data gaps. Results are also compared with those from inventories for SNC for the base year 2000 and INC for the base year 1994.

The overall results of this inventory are presented in the tables below. The net GHG emissions of 28,166.06 Gg CO_2-eq was estimated for Nepal in the base year 2011. This marks a significant increase from the emissions (13,447 Gg CO_2-eq) of the base year 2000/01 (Table c). The inventory results are also used in developing trends of emissions to the year 1990 and projecting to the year 2030.

Summary Tables of Nepal's GHG Emission and Removal 2011

(a) Direct Gases, 2010/11

Sector, Sub-sectors	Net 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. Agriculture, Forestry and Land Use (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	**173.98**				
Biomass Combustion for Energy Production	**23,499**				

(b) Indirect Gases, 2010/11

Sector, Sub-sectors	Emission of indirect Gases (Gg)			
	NOx	**NMVOC**	**CO**	**SO_2**
TOTAL	**2.87**	**6.00**	**186.44**	**0.20**
1. Industrial Processes and Product Use	0.00	6.00	0.00	0.20
2 AFOLU	2.87		186.44	
Aggregate Sources and Non-CO_2Emissions Sources on Land (3C)	2.87		186.44	

(c) Summary of GHG Emissions in Three Inventories

Computed CO_2-eq (Gg)	1994/95	2000/01	2010/11
Emission	54,043	26,222	54028.73
Removal	14,778	12,775	25862.67
Net	**39,265**	**13,447**	**28166.06**

Along with presenting the results, this TNC highlights the need of more effort in addressing data gaps, inconsistencies, and uncertainties in GHG inventory. It makes the case for achieving required disaggregation and detail in activity data and developing Nepal-specific emission factors.

C. Greenhouse Gas Mitigation Assessment

The GHG mitigation assessment presents the trends and projections of GHG emissions from different sectors, evaluates different mitigation options and policies for these sectors, and develops mitigation action plans. It uses the data from GHG inventory as well as those from other government and industry sources. It identifies key categories in four sectors (energy, AFOLU, IPPU and waste) and presents analysis according to IPCC 2006 Guidelines. The most promising mitigation options in each of the sectors are selected and Multi-Criteria Analysis (MCA) carried out to ascertain their validity. An analytic hierarchy Process (AHP) was carried out using Expert Choice program to finalize climate change mitigation options.

The results show that the IPPU sector shows a significant increase in the projected GHG emission by 2050. The GHG emissions from IPPU sector will be greater than that of the AFOLU and energy sector. But, projected GHG emission from the AFOLU does not show significant variation. The assessment shows that the energy sector can play a crucial role in Nepal's GHG mitigation effort. Similarly, the planning of industrial development will be of vital importance in this effort.

This assessment suggests that the following will be major mitigation options for each sector:

- *Energy Sector*: Energy saving policies; enhancing energy efficiency; cogeneration in industries; using renewable energy technologies.
- *AFOLU Sector*: Intercropping or successional planting system; zero tillage; conservation agriculture; forest management; urban forestry; dietary changes in livestock; grazing land management.
- *IPPU Sector*: Energy efficient production process; replacing high-carbon fuels with low carbon fuels; removal of CO_2 from the flue gases.
- *Waste Sector*: Land filling with landfill gas recovery; proper disposal and treatment of waste; prevention of waste generation; waste recycling.

This assessment ranks a list of various mitigation options into the priority order. In agriculture sector, the highest rank was given for agricultural conservation practices, followed by climate-smart agriculture, organic farming and crop-water management. In Forestry sector, reducing deforestation received the highest rank, followed by afforestation, community-based forestry, and agroforestry. In livestock sector, animal fertility and productivity were ranked higher. The highest rank in waste sector was given to reduction and control of open burning, followed by reducing land-filling. In IPPU sector, cleaner production and alternative raw materials were ranked higher. Likewise, solar PV systems, induction lighting and cooking, electric cooking, electric railways and vehicular emission control received the highest ranking in the energy sector. A range of mitigation options are also identified for energy-related sub-sectors, including energy production, efficiency, residential, transportation and policy-based options.

On the basis of the above exercise, a mitigation action plan is formulated for each sector. An appropriate time-frame and the agency responsible for implementation are assigned for each action. For example, in the energy sector, implementation of *Solar PV systems* should be supported by the provincial government in policy and financial arrangement; and this option should be

implemented over the short to long term. In the AFOLU sector, *agricultural conservation practice* is a mitigation option under the responsibility of local government; it needs an immediate action for promoting mulching, crop rotation, or residue management. In the IPPU sector, *clean production* involves the replacement of fossil fuels with clean energy sources; this is the responsibility of federal or provincial government. *Control of open burning* as a mitigation option for the waste sector needs immediate action and the local government is responsible agency.

D. Vulnerability, Impact and Adaptation Assessment

The Vulnerability, Impact and Adaptation (VIA) component comprises an assessment of climatic vulnerability in Nepal, its impacts in key sectors, and related policy and measures. Following Nepal's National Adaptation Programme of Action (NAPA), the assessment focuses on these eight sectors:

a. Agriculture and food security
b. Water resources and energy
c. Forests and biodiversity
d. Public health and water, sanitation and hygiene (WASH)
e. Tourism, natural and cultural heritage
f. Urban settlement and infrastructure
g. Climate-induced disasters
h. Gender and social inclusion.

The VIA assessment presents information and analysis of vulnerability in Nepal in general and in the above eight sectors. It employs analysis of trends and projections, scenario analysis and IPCC's vulnerability framework. It develops trends and projections for precipitation and temperature. To understand the projected change, two Representative Concentration Pathways (RCPs) scenarios are selected: RCP4.5 and RCP8.5. The scenarios for the medium-term (2016-2045) and long-term (2036-2065) are prepared by comparing with the reference period 1981-2010.These analyses are used in understanding vulnerability and impacts that the sectors face due to climate change.

Results on observed climate trend of Nepal show a rise of $0.056^{0}C\ yr^{-1}$ in annual maximum temperature, statistically significant at 99.9%, and $0.002\ ^{o}C\ yr^{-1}$ in minimum temperature, which is not statistically significant even at 95%. The maximum temperature trend showed a clear signal of country-wide warming with the highest rate of increase in higher altitudes. But the minimum temperature data does not show as clear a signal. Similarly, the average annual precipitation is likely to increase by 2-6% in the medium-term (2016-2045) and 8-12% in the long-term (2036-2065) in reference to the 1981-2010 period. Annual mean temperature is likely to increase by 0.9-1.1 ^{o}C in the medium-term and 1.3-2.8 ^{o}C in the long-term. Warm extreme temperature indices are likely to increase, while cold extreme indices are likely to decrease in the future. Frequency of extreme precipitation events are likely to increase in the future. Uncertainties are high in precipitation projections, while it is small in temperature projections.

This VIA assessment also reviews Nepal's regulatory framework, policies, plans and programmes for climate change adaptation. Then it assesses different climate change adaptation measures adopted in these sectors and, subsequently, proposes an action plan for each of them.

Vulnerability and Impact Assessment

This VIA assessment shows that climate change will have noticeable impacts in the eight sectors identified above. Agriculture is a major sector of the economy in Nepal; it engages two thirds of the population and contributes approximately 27% the GDP. Poor and vulnerable farming populations suffer from under nutrition. Malnutrition contributes to increase in child mortality and lowering of life expectancy. This sector is highly vulnerable to climate change, especially due to increased temperatures and change in precipitation patterns. Agriculture is highly exposed to climate-induced hazards and extremes events, impacting crop and livestock production. But the adaptive capacity of most farmers is limited. Some adaptation actions are in practice, but need further revision. The sector requires initiatives to help farmers to adapt to climate change.

Water resources and energy. Nepal has immense potential for the use of water resources; yet only <7% of total available resources has been utilized so far. Energy use in the country is dominated (80%) by biomass as a primary source whilst hydropower energy dominates in total electricity supply (63%). The climate variability has impacts on the resource endowment, energy supply, energy use, and water-energy infrastructure settings. In terms of resources endowment, climate change affects water availability. The loss of glaciers and associated alterations in hydrology affects water availability, its timing, and subsequently, energy production. The contribution of snow and glacier melts to total water discharge during the period of 1985 to 1997 was about 34% annually, whereas it was 63% in the pre-monsoon season (March to May). Future impacts on hydro-electricity generation depends on various factors, but in general hydropower generation potential will increase initially with the rise in temperature, and then decrease gradually. Vulnerability of water resources sector is exacerbated by the climate variabilities and changes. Hydro-power generation will be further impacted by increasing disasters such as those resulting from sedimentation, flooding, and geo-hazards.

Any substantial change in the frequency of floods and droughts, or in the quantity and quality of water or seasonal timing of water availability, will require adjustments that can be costly in monetary, societal and ecological terms. While adaptation measures for water sector depends certainly on context and location, some generic ones include investing on data and information; establishing and operationalizing early warning systems; lowering of glacial lakes; and making the water-energy infrastructure climate resilient.

Forests and biodiversity. Forests and biodiversity are crucial climate sensitive sector in Nepal (NAPA, 2010; NAP, 2017). Some of the identified impacts of climate change on forests and biodiversity are (i) shifts in agro-ecological zones, prolonged dry spells, and higher incidences of pests and diseases, (ii) increased temperature and rainfall variability, (iii) increased emergence and spread of invasive alien plant species, (iv) increased incidence of forest fires in recent years, (v)

changes in phenological cycles of tree species, (vi) shifting of treeline in the Himalaya, and (vii) depletion of wetlands.

Besides, mountain plants will be affected by overall warming or due to changes in precipitation pattern. Due to climatic stress such as less water, and change in weather patterns, medicinal plants in high-altitude rangelands become more vulnerable and decrease in quantity. Temperature rise has led to upward shift of ecological belts, such as in case of tree lines of *Abies spectabilis* and *Betula utilis*. Reduced snowfall, untimely rains, and increased dryness have also altered the flowering and fruiting behaviour of plants, which impact the survival of wildlife.

Public Health and WASH. The projected impacts in human health due to climate change include increase in cardiovascular disease mortality in tropical region, increase in vector borne and water borne diseases, and increase in heat-related mortality and morbidity. It is already evident that malaria, Kalaazar, Japanese encephalitis, and other water borne diseases such as typhoid and cholera are commonly seen in different parts of the country. Likewise, heat waves, cold waves, diseases and hazards such as floods and landslides lead to greater risks of disease outbreaks.

Tourism, Natural and Cultural Heritage. Climate change induced disasters impact the tourism industry, both directly and indirectly by damaging tourism-related infrastructures and resources, and disturbing tourism activities, water supply, organic farming, and the wellbeing and vitality of tourism service providers. Receding snowlines, melting glaciers, increased frequency of cloudbursts, floods, and landslides have the potential to change the nature and quality of tourism resources. Activities of major tourist attraction, like mountaineering, trekking, and rafting are directly affected by climate change.

Infrastructure and Urban Settlement. Almost two-thirds of Nepal's population now lives in areas officially designated as municipalities. On one hand, settlements across the country are rapidly urbanizing. On the other hand, climate change is directly affecting water and other natural resources on which the population critically depends upon. Most settlements, whether in Mountains, Hills or Terai, have already been experiencing water scarcity. Many cities experience 'urban heat island' effect caused by the heating of concrete and asphalt surfaces, which is leading to health concerns and more energy demand for cooling.

Likewise, heavy and untimely rainfall has increased threats of landslides, floods and debris flow. Ironically many settlements are built on steep slopes prone to landslides and riverbanks prone to floods. Urban floods, dispersion of pollutants to water bodies, and outbreaks of water and vector-borne diseases are increasing in the cities during monsoons or heavy rains. Damage to roads and drainage structures cause huge economic loss in cities, as transport services and overall daily lives are disrupted.

Climate Induced Disasters. Disaster events such as Glacial Lake Outburst Floods (GLOFs), landslides, floods, Landslide Dam Outburst Floods, windstorm, hailstorm, avalanche, fog, cold waves and heat waves are common in Nepal. Moreover, increased melting of snow and ice including

permafrost can induce an erodible state in the mountain soil which was previously non-erodible. This has increased likelihoods of landslides in the mountains. The Government of Nepal (GoN) has been making efforts to reduce vulnerability from the climate induced disasters.

Gender and Social Inclusion. While climate change affects biophysical systems, it ultimately impacts on society, such as by affecting their lives and livelihoods. Many women, men and socially excluded communities depend critically on the ecosystems and natural resources, which serve the society with food, fibre and shelter. Different communities associate cultural meanings and a sense of place to such ecosystems and resources. The depletion of ecosystem services negatively affects food security of the poor and marginalized communities but also causes displacement and further marginalization. It also decreases the adaptive capacity of men and women from socially excluded groups.

The marginalized or indigenous groups, particularly *Majhi, Raute, Chepang, Satar* experience reduced food insecurity due to disasters like floods, landslides, fire and windstorm. Women as primary caretakers of water and forest resources face an increased work burden with the depletion of the resources. There has been challenge for the women, men and socially excluded communities and groups on how to cope with and adapt to extreme climatic events.

Adaptation Actions. Overall, the VIA assessment shows that Nepal faces profound challenges from climate change. The report discusses adaptation policies, laws and measures adopted in each of the eight sectors. It has put forward adaptation action plans for each of them; some of the actions are as follows:

- Agriculture and Food Security: improved governance, commercialization of agriculture and increased competitiveness.
- Water Resources and Energy: disaster monitoring and risk reduction, watershed management, improved irrigation system
- Forests and Biodiversity: sustainable management of forests, promotion of non-conventional energy sources, the control of forest fire and over-grazing
- Public Health and WASH: capacity development of health care professionals, monitoring of air quality and air-borne diseases
- Tourism, Natural and Cultural Heritage: sustainable tourism, eco-cultural trekking trails, application of early warning systems
- Infrastructure and Urban Settlement: risk-sensitive land use planning, construction of climate-resilient infrastructure, investment in green and blue infrastructure, increased insurance coverage
- Climate Induced Disasters: Develop disaster risk reduction plans, local level planning for DRR, strengthening the capacity for disaster response
- Gender and Social Inclusion: equal representation of women in decision making and policy formulation on climate change; enhancement of special livelihood skills to the marginalized, poor and disadvantaged families.

E. Constraints and Gaps, and Related Financial, Technical and Capacity Needs

This TNC presents in detail the constraints and gaps during its preparation. These include:

- Uncertainty in GHG Inventory and Data Quality, mainly as Nepal does not have country-specific emission factor and activity data in sufficient detail.
- Inadequate and uneven spatial coverage of meteorological and hydrological observational networks.
- Inadequate human resource and lack of updated technology and equipment in the Department of Hydrology and Meteorology.
- Low priority and inadequate institutional arrangement for research and development in adaptation and mitigation technologies.
- Inadequate institutions and incentives for developing and using technologies for adaptation and mitigation.

F. Other Relevant Information

This TNC presents additional relevant information on the following:

- Nepal's efforts at integration of climate change into Nepal's development priorities, plans and programmes
- Technology needs assessment
- Climate change related research and systematic observation
- Education, Training and public awareness
- Networking and information sharing.

1. INTRODUCTION

This is the Third National Communication (TNC) submitted by the Government of Nepal to the United Nations Framework Convention on Climate Change (UNFCCC). Nepal signed the UNFCCC on 12th June 1992, and ratified it on 2nd May 1994, making it effective from 31st July 1994. Since then, Nepal has been actively participating in the UNFCCC. It has also taken measures - policies, plans, programmes and activities – in its efforts for tackling climate change.

This TNC represents the continuation of two previous communications of Nepal, viz., the Initial National Communication (INC) of 2004 and the Second National Communication (SNC) of 2014. It provides updated information on the country's national circumstances, greenhouse gas inventory, greenhouse gas (GHG) mitigation assessment, vulnerability and adaptation assessment as well as policies, plans, programmes and activities designed or undertaken to address climate change. It also presents other relevant information towards achieving the objective of UNFCCC. This includes activities of integrating climate change into national development planning; technology development and transfer; capacity building; research and systematic observation; education, training and public awareness; networking and information sharing; and related constraints and gaps and financial, technical and capacity needs.

This TNC report has the following main chapters.

Chapter 2 National Circumstances presents the contextual and background information on Nepal's socio-economic, biophysical and governance aspects.

Chapter 3 National Greenhouse Gas Inventory presents the results of inventory of GHG emissions by sources and removals by sinks, developed with IPCC methods, for the base year 2011.

Chapter 4 Greenhouse Gas Mitigation Assessment enumerates mitigation measures and policies, assesses different options, and presents mitigation action plan.

Chapter 5 Vulnerability and Adaptation Assessment identifies Nepal's climate change adaptation policies and measures, evaluates available options, and presents adaptation action plan for key sectors impacted by climate change.

Chapter 6 Constraints and Gaps, and Related Financial, Technical and Capacity Constraints presents relevant constraints and gaps observed during the preparation of this TNC.

Chapter 7 Other Relevant Information presents further information relevant to Nepal's efforts at adaptation to climate change and mitigation of GHG emissions.

2. NATIONAL CIRCUMSTANCES

2.1. Introduction

This chapter presents Nepal's contextual and background information comprising national circumstances. This includes a brief description and information of physical and socio-economic characteristics, natural resources, governance restructuring and coordination mechanisms, and climate change policy and measures adopted by the Government of Nepal (GoN).

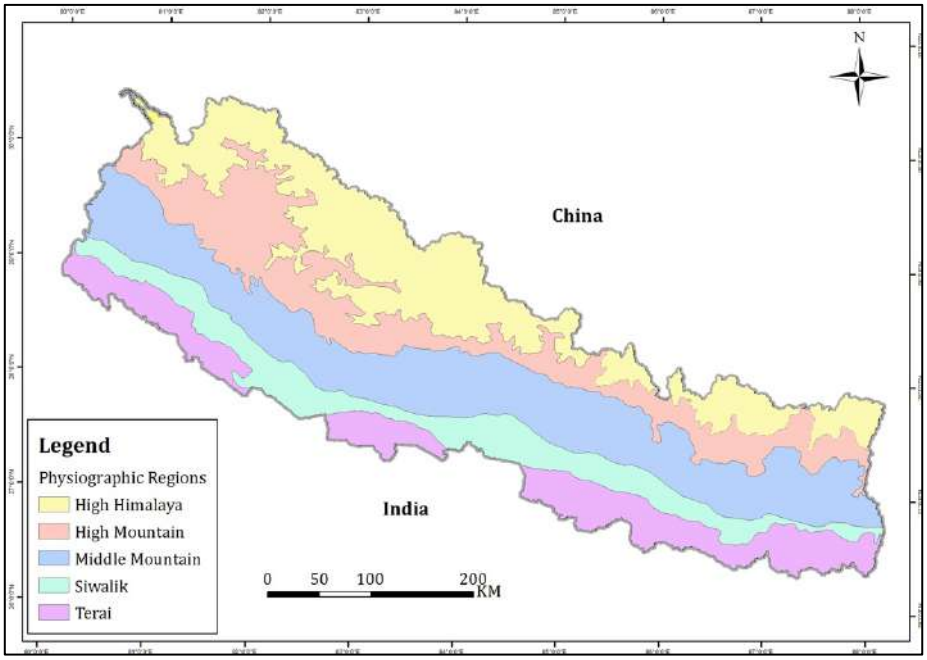
The physical features covered in this chapter include geography and physiography of Nepal, its climate characteristics, and land use and land use change. Socio-economic dimensions cover demography and urbanization, economy, energy, hydropower development, agriculture and livestock, industry, tourism, road and transport, and water, sanitation and hygiene (WASH). Similarly, natural resources characteristics include forests and biodiversity, water resources and minerals. Governance and coordination mechanisms cover recent changes brought about by Nepal's restructuring into federal system and some of its implications on climate change coordination. The final section on policies and measures includes main initiatives on climate change taken up by the GoN, a highlight of major policies and the allocation of budget.

2.2. Physical Features

2.2.1. Geography and Physiography

Nepal is located on the southern slopes of the Central Himalaya between 26°22' and 30°27' N latitudes and 80°04' and 88°12' E longitudes. It covers an area of 147,181 sq. km. and is roughly rectangular in shape with 885 km of length along east-west direction, and 145 km to 241 km of width along north-south direction. It is landlocked, bordering with China in the north and with India in the east, south, and west.

Figure 2-1: Physiographic zones of Nepal



Source: Survey Department, 2020.

Vast majority of the area of Nepal consists of mountains and hills, and the remaining area is covered by low-lying Terai plains. Along the country's South-North axis, altitude changes rapidly. Within a short span of 145 km to 241 km, the altitude ranges from 67m above mean sea level in the south to 8849 m in the north at the peak of Mt. Everest.

The country is divided into five physiographic regions along the east-west direction (Figure 2-1). The physiographic zones include: (1) Terai, (2) Siwalik (Churia), (3) Middle Mountains, (4) High Mountains, and (5) High Himal.

2.2.2. Climate

Nepal's climate is influenced by the Himalayan mountain range and the South Asian monsoon. Table 2-1 presents the climatic characteristics of the country's five physiographic zones, including their share of area, elevation range, precipitation and temperature.

Table 2-1: Climate characteristics in different ecological belts Nepal

Physiographic zones	Area share (%)	Elevation (m)	Climate	Average annual precipitation (mm)	Mean annual temperature (°C)
Terai	14	below 500	Hot monsoon and Tropical	1100-3000	20-25
Siwalik	13	500-1,000	Hot monsoon and Subtropical		
Middle mountains	30	1,000-2,000	Warm temperate monsoon		
		2,000-3,000	Cool temperate monsoon	275-2300	10-20
High mountains	20	3,000-4,000	Sub-alpine		
		4,000-5,000	Alpine	150-200 (snow)	<3-10
High Himal	23	Above 5,000	Tundra-type and Arctic		

Source: WECS, 2005 cited in MoE, 2010).

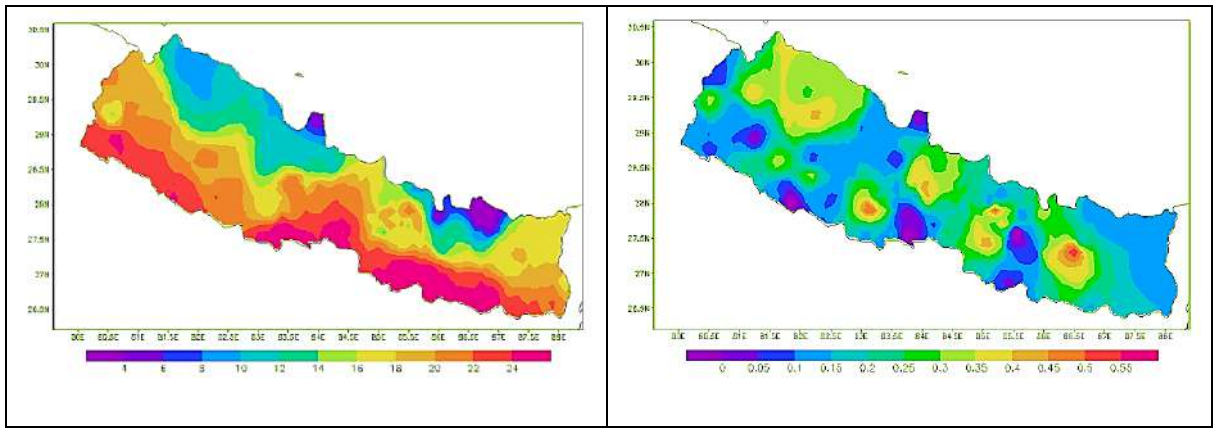
Similarly, Nepal's weather is divided into the following four seasons (NCVST, 2009):

a. March – May: Hot, dry pre-monsoon
b. June – September: Monsoon season in which about 80% of the annual rainfall occurs for much of the country
c. October – November: Post-monsoon, transitional period
d. December – February. Winter season, which is cold and dry with occasional snowfall in the High Mountain and Himalaya.

Temperature trend. Observations show a general decrease in the annual mean temperature from south to north as elevation rises. In mean annual distribution, the Terai region recorded the maximum temperature (over 24°C) and High Mountainous region recorded the lowest minimum temperature (below 4°C) (Figure 2-2, left). All-Nepal annual mean temperature ranged from

minimum 11.6°C to maximum 23.6°C. Except for small isolated pockets, most of the country showed an increasing trend of temperature rise up to 0.55°C per decade (Figure 2-2, right). An analysis of temperature data from 49 weather stations for the period 1971-1994 showed warming trends after 1977 ranging from 0.06° to 0.12°C yr^{-1} in most of the Middle Mountain and Himalayan regions, while Chure and Terai regions show warming trends less than 0.03°C yr^{-1}(Shrestha et al 1999). Likewise, data from 45 weather stations show a consistent and continuous increase of 0.04°C yr^{-1}in maximum temperature during 1996-2005 (Practical Action 2009). Both studies indicate that the warming trend in the country is spatially variable.

Figure 2-2: Annual mean temperature (˚C) (left) and trend (˚C/ decade) (right)

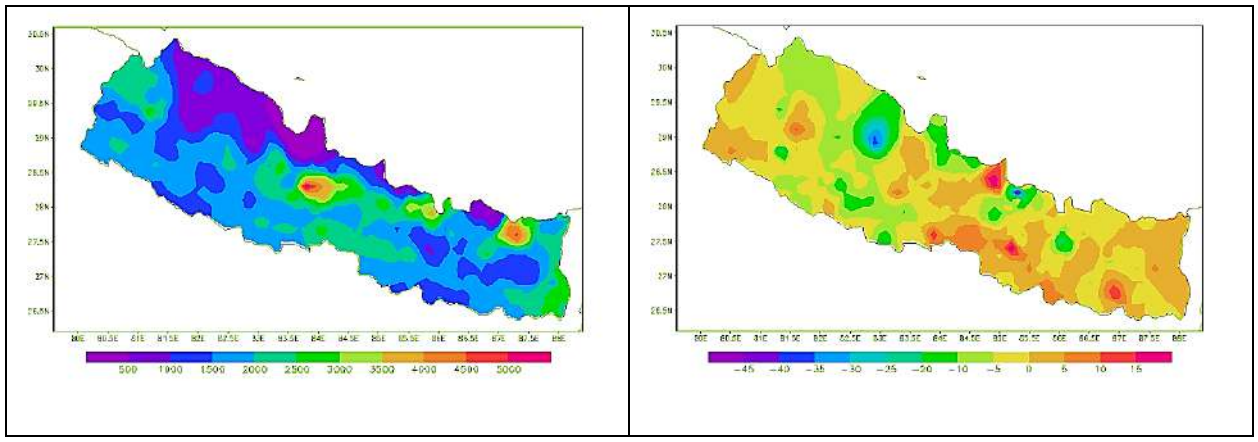


Source: MoSTE, 2014

Precipitation trend. Highest precipitation in Nepal (over 5000 mm) is observed in the southern flank of Annapurna range whereas driest part (with about 500 mm precipitation) is observed on the lee side of the same range (Figure 2-3, left). In addition, eastern high-altitude regions have two pockets of about 3000 mm annual precipitation. Rest parts of the country have precipitation distribution of approximately 1000-2000mm, which increases towards northern mountains, except over western part of the country where it decreases towards north. All-Nepal average annual precipitation is 1683 mm of which 1330 mm falls during summer monsoon.

In general, precipitation trend is positive in most of the country with maximum increase of about 15% per decade in few isolated pockets (Figure 2-3, right). Some places in western Nepal show a negative trend. Except in the north-western rain-shadow region, around 80% of annual precipitation is contributed by summer monsoon.

Figure 2-3: Annual precipitation (mm) (left) and trend (% of annual /decade) (right)



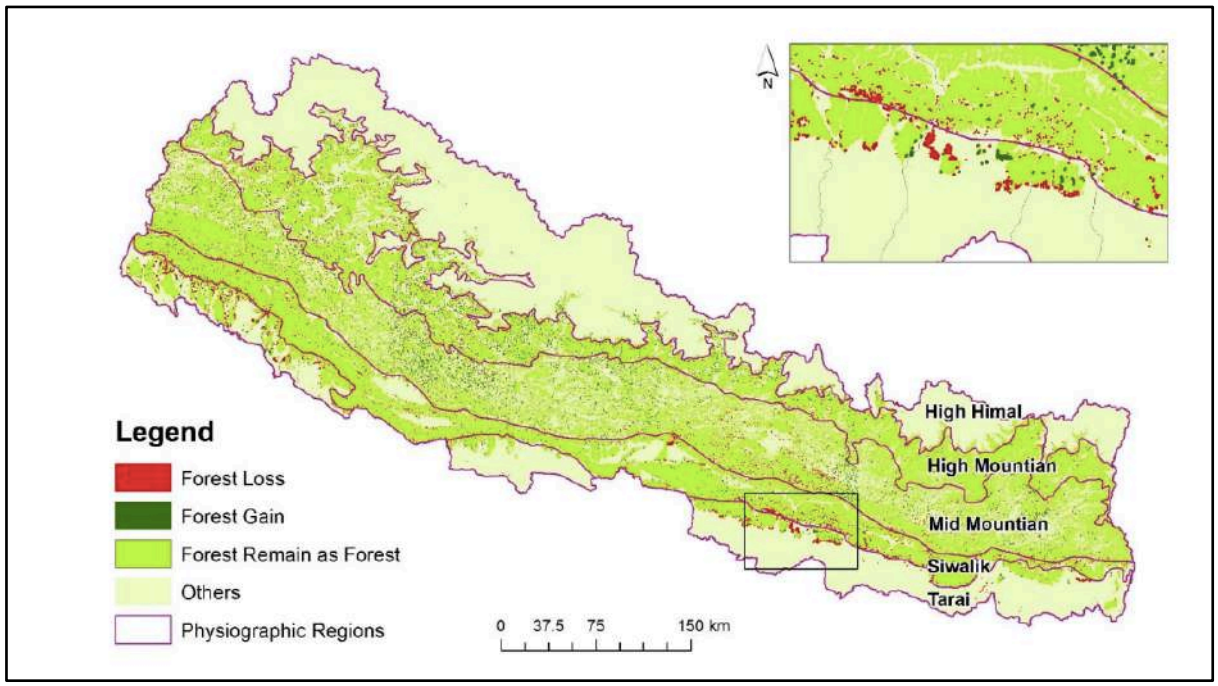
(Source: MoSTE, 2014).

MoE (2010) records no significant trend in terms of precipitation data with large inter-annual variation in rainfall, particularly monsoon precipitation, which could be a part of natural cycles.

2.2.3. Land Cover and Land Cover Change

The distribution of land-cover (forest and non-forest and the change over the duration of 2000 to 2010) in Nepal is shown in Figure 2-4.

Figure 2-4: Land cover and land cover change map of Nepal (2000-2010)



(Source: MoFSC, 2017).

Over the past decades, there has been significant conversion from forest land to cropland and other land uses (Uddin et al 2015). Similarly, croplands were also converted to other land uses especially

settlements in the areas adjacent to urban centers. Table 2-2 shows the status of the forest and non-forest land cover classes and its changes over the period between 2000 and 2010.

Table 2-2: Land classes change from 2000 to 2010 in Nepal (Area in ha)

Land Class	Year 2000		Year 2010		Area change between 2000 and 2010 (Ha)
	Area (Ha)	%	Area (Ha)	%	
Forest	5,945,220.6	40.39	5,937,644.4	40.34	-7576.2
Other Landcover (Non-Forest, including shrublands)	8,772,879.3	59.61	8,780,455.5	59.66	+7576.2
Total	**14,718,100**	**100**	**14,718,100**	**100**	**0**

Source: MoFSC, 2017

2.3. Socio-Economic Dimensions

2.3.1. Demography and Urbanization

Nepal is a multi-ethnic, multi- lingual and multi-cultural country. Nepal's population comprises over hundred ethnic groups, who speak 92 languages. About 81.3% of the population are Hindu, while 9.0% are Buddhist, 4.4% Muslim, and 3.1% Kirant (CBS, 2012). Over the past five decades, Nepal's population has increased almost three-fold (Table 2-3).

Table 2-3: Population and growth rate

Year	1961	1971	1981	1991	2001	2011
Population (millions)	9.4	11.6	15.0	18.5	23.2	26.5
Annual growth rate	1.65	2.07	2.66	2.09	2.24	1.35

Source: National census data of relevant years, Central Bureau of Statistics.

The key population and demographic results of the National Population and Housing Census 2011 are summarized in Table 2-4.

Table 2-4: Key results on population and demography from Census 2011

Description	Details
Total population	26,494,504 (with growth rate: 1.35%)
Regional distribution	Terai:50.27% (13,318,705); Hill: 43% (11,394,007); Mountain: 6.73% (1,781,792).
Total number of households	5,427,302
Household size	4.88.
Sex ratio	94.2 (99.8 in 2001). 796,422 more females than males.
Population density in districts (persons per sq. km)	180 (157 in 2001).
Urban population (population in	17 % (4,523,820) [13.94% (3,227,879) in 2001].

Description	Details
then 58 municipalities)	
Working age population (aged 15 to 59 years)	57% (15,091,848) [54% (12,310,968) in 2001].
Female-headed households	25.73% (14.87% in 2001).
Caste/ethnicity	125 caste/ethnic groups.
Mother tongue	123 languages.
Religion	10 religion categories.
Disability	1.94% (513,321).
Literacy rate (for population aged 5 years and above)	65.9% (54.1% in 2001). Male literacy rate: 75.1%, female literacy rate: 57.4%.

(Source: CBS, 2012).

In Nepal, the level of urbanization is defined in terms of the ratio of municipal population. Table 2-5 shows the changing number of municipalities, their population and percentage share since 1950s. Currently, the municipalities comprise six metropolitan cities, 11 sub-metropolitan cities and 276 municipalities, and are categorized as such according to a set of criteria related to population, infrastructure, and revenues. During the 2011 census, there were 58 municipalities, and about 17% of the population lived in urban areas, and remaining 83% in rural areas. But census has yet not been carried out after the restructuring of local government units in 2017. This restructuring has established 753 local units, comprising 296 urban local jurisdictions (municipalities), and 460 *Gaupalika* (rural Municipality). Accordingly, urban population has increased from 9.2% in 1991, 17.1% in 2011 to 58.4% in 2017 (MoFALD, 2017; Joshi 2019).

Table 2-5: Urban growth in Nepal

Census Year	No. of municipalities	Population	Percentage of total population	Urban-rural population ratio	No. of municipalities added	AAGR (%)*
1952/54	10	238,275	2.9	0.03	-	-
1961	16	336,222	3.6	0.04	6	-
1971	16	461,938	4.0	0.04	0	3.18
1981	23	956,721	6.4	0.07	7	7.28
1991	33	1,695,719	9.2	0.10	10	5.72
2001	58	3,227,879	13.9	0.16	25	6.44
2011	58	4,523,820	17.1	0.21	0	3.38
2014 May**	130	7,199,514	27.2	0.37	72	-
2014 Dec	191	-	-	-	61	-
2015 Sep	217	>11 million	42***	0.72	26	-
2017	293		58.4****	-	76	-

Source: Based on CBS data cited in Subedi (2014) with additional input. Note: *Average annual growth rate (exponential). **Additional note: 61 new municipalities were declared again in December 2014, and 26 in September 2015). *** Official estimate; **** MOFALD 2017& Joshi 2019).

2.3.2. Economy

Nepal's per capita GDP in current price was USD 1,085 (NPR 126,018) in FY 2019/20. The major macroeconomic indicators and trends over FY 2006/07 to 2015/16 are presented in Annex 1. The Nepalese economy has seen declining contribution of agriculture (agriculture, forest and fisheries) and industry sectors to the Gross Domestic Product (GDP) whereas contribution of the service sector has been rising. Agriculture contributed 36.6% to GDP in FY 2001/02, which dropped to 31.6% in FY 2015/16, while non-agriculture sector went up from 63.4% to 68.3% in the same period (MoF 2016). In FY 2019/20, the contribution of agriculture sector to total GDP further declined to 27.7% (MoF 2020).

Reliance on remittance: The share of remittance to GDP remained at 18.5% in FY 2010/11 which rose to 29.1% in FY 2014/15 (MoF 2016). In the next five years, the share has been fluctuating between 25% to 30% of GDP – e.g., it peaked at 29.5% in 2015/16, whereas it was 25.4% in 2018/19 (MoF 2020).

Poverty: Since early 1990s, Nepal emphasized poverty alleviation in its policies. By 2012/13, population living below poverty line reduced to 23.8% from 42%. The 13th National Plan (2013-16) aimed at reducing population living below poverty line to 18%, but the progress was 21.6% (NPC, 2017). At the beginning of 15th Plan (2019), 18.7% people below absolute poverty while 28.6% below multi-dimensional poverty (NPC 2019).

Employment: As per the Nepal Labor Force Survey 2017, about 500,000 individuals enter labor force every year. But labor participation rate over 15 years was 38.5% in 2017, as there is huge gap between the demand and supply of labor and there is not enough employment opportunity. Some key indicators of employment are presented in Table 2-6.

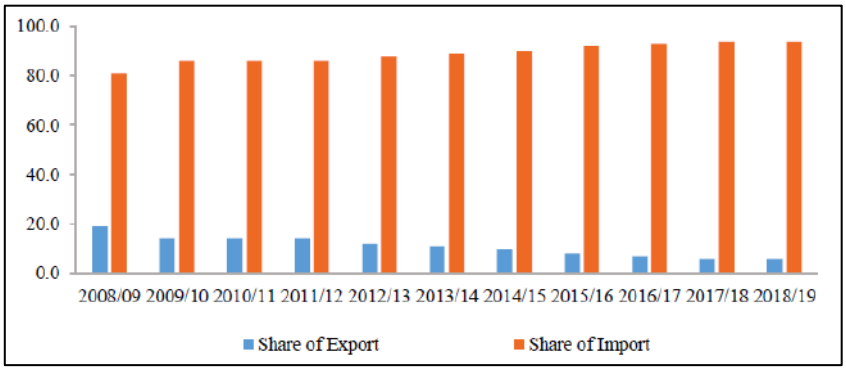
Table 2-6: Main Employment Indicators of Nepal

Indicators	Female	Male	Total
Ratio of Employment to Population (%)	22.9	48.3	34.3
Labour Force participation rate (Above 15 years old, Percent)	26.3	53.8	38.5
Unemployment rate (In thousand)	397	511	908
Under- utilization rate of labour (Percent)	48.7	31.8	39.2
Employment rate in informal sector (Percent)	32.3	39.0	36.5
Average working time in major profession (per week/hour)	39	48	-
Employment in informal sector (Percent)	32.9	45.8	41.0

Source: MoF 2020

Trade: Nepal's trade deficit has been growing over time, but since FY 2018/19 the export growth has been high. In FY 2018/19, export increased by 19% and imports by 13.9%. The country's high dependence on the import of petroleum as compared to the smaller revenue of export and recent increases in the import of agricultural and essential goods has led to consistently high trade deficit (MoF, 2016). Figure 2-5 presents the share of import and export in total trade.

Figure 2-5: Share of Import and Export in Total Trade (%)



Source: MoF 2020, p.55.

2.3.3. Energy

Traditional sources of energy dominate the supply of energy in Nepal (Table 2-7).

Table 2-7: Energy consumption by source

(Quantity in '000 Tons of oil equivalent)

Source	FY 2013/14		FY 2014/15		FY 2015/16*	
	Quantity	%	Quantity	%	Quantity	%
Traditional	**8983**	**79.97**	**9104**	**62.13**	**6069**	**55.32**
Firewood	*8154*	*72.59*	*8264*	*56.40*	*5509*	*50.22*
Agricultural residues	*403*	*3.59*	*408*	*2.78*	*272*	*2.48*
Cow Dung	*426*	*3.79*	*432*	*2.95*	*288*	*2.63*
Commercial	**1958.96**	**17.44**	**5256.90**	**35.88**	**4609.77**	**42.02**
Coal	*320*	*2.85*	*465*	*3.17*	*192*	*1.75*
Petroleum Products	*1264*	*11.25*	*4294.62*	*29.31*	*4143.46*	*37.77*
Electricity	*374.96*	*3.34*	*397.28*	*2.71*	*274.31*	*2.50*
Renewable	**291**	**2.59**	**291.64**	**1.99**	**291.86**	**2.66**
Total	**11232.96**	**100.00**	**14652.54**	**100.00**	**10970.63**	**100.00**

(Source: Ministry of Energy cited in MoF, 2016. * Of first eight months).

Electricity

In the FY 2014/15, the total electricity production stood at 829.19 MW while it reached 847.68 MW in FY 2015/16 against the demand of 1,385 MW (Table 2-9). By mid-March 2016, transmission line has reached 3216.86 km with the number of electricity users reaching 2,922,041. During the same period, the electricity distribution line has been extended to 123,977 km. There was acute power shortage from mid 2000s through to late 2010s.

Table 2-8: Electricity demand, consumption, production and physical structures

Description	FY 2010/11	FY 2011/12	FY 2012/13	FY 2013/14	FY 2014/15	FY 2015/16*
Production (MW)	697.85	705.57	746.00	746.00	829.19	847.68
Transmission line (km)	1917.62	1987.36	1987.36	1987.36	2848.86	3216.86
Customer number	1854275.00	2053259.00	2599152.00	2713804.00	2872015.00	2922041.00
Distribution line (km)	89108.86	95815.98	114160.40	116066.64	123827.78	123976.78
Available energy (GWh)	3389.27	3858.37	4260.45	3092.47	4966.66	3428.90
High demand (MW)	946.10	1026.00	1094.00	1200.98	1291.10	1385.00

* Of the first eight months. Source: Ministry of Energy cited in MoF (2016).

However, electricity generation increased in recent years, growing up to 1182MW by FY 2018/19. With growth in domestic production and import from India, acute power shortage experienced in urban areas has largely ceased to exist during the past couple of years.

Renewable energy

The GoN has a policy to develop and extend alternative energy to contribute to maintaining environment balance, employment generation, and inclusive development. GoN aims to generate renewable and alternative energy comprising 10% to total energy consumption and covering 30% of the population having access to electricity in next 15 years. About 16% of the total population is availing electricity service through renewable sources (Table 2-9). Likewise, about 27% of the total population are estimated to have access to clean renewable energy.

Table 2-9: Alternative Energy Usage Status, 2010/11 – 2015/16

Major Programs	FY 2010/11	FY 2011/12	FY 2012/13	FY 2013/14	FY 2014/15	FY 2015/16*
Electricity generated through micro and small hydroelectricity project (KW)	2,453	3,258	3,366	3,288	3,346	1,095
No. of Solar domestic electric system installation	57,059	35,627	96,495	87,038	103,161	23,994
No. of Solar dryer/cooker distribution	272	202	140	202	30	-
No. of Bio-gas installation	17,907	18,979	17,635	31,512	30,078	14,351
Improved water mill installation	353	971	1,256	341	641	308
Improved stove installation	84,168	118,461	120,364	140,662	310,281	61,576

(Source: Alternative Energy Promotion Center cited in MoF (2016). *of first eight months).

Use of petroleum products

Consumption of petroleum products, which is an important source of energy, has been growing over time (Table 2-10). Consumption of petrol, diesel, LPG and aviation fuel has been growing every year while that of kerosene is just the opposite. This is because LPG is used as an alternative. The consumption of LPG has grown 11 to 12% a year over several years.

Table 2-10: Consumption of petroleum products, 2005/06-2015/16

Fiscal Year	Petrol(kl)	Diesel (kl)	Kerosene (kl)	Aviation Turbine Fuel (kl)	Light Diesel Oil(kl)	Furnace Oil (kl)	Total excluding LPG (kl)	LPG(MT)
2015/16*	88423	254103	5870	33239	-	-	381635	73440
2014/15	283567	901393	18628	139404	-	-	1342992	258299
2013/14	251451	811100	19064	123527	-	-	1205142	232660
2012/13	221676	716747	24721	115786	258	2450	1081638	207038
2011/12	199749	648513	41808	108908	0	435	999413	181411
2010/11	187641	655128	49495	101314	227	1415	995220	159286
2009/10	162275	612505	55788	82631	238	2589	916026	141171

Fiscal Year	Petrol(kl)	Diesel (kl)	Kerosene (kl)	Aviation Turbine Fuel (kl)	Light Diesel Oil(kl)	Furnace Oil (kl)	Total excluding LPG (kl)	LPG(MT)
2008/09	124169	446468	70089	68935	377	2171	712209	115813
2007/08	100842	302706	155216	68938	306	2919	630927	96837
2006/07	101912	306687	197850	63778	179	4558	674964	93562
2005/06	80989	294329	226637	64335	290	3695	670275	81005
Total	**1802694**	**5949679**	**865166**	**970795**	**1875**	**20232**	9610441	**1640522**

(Source: Nepal Oil Corporation cited in MoF (2016). *Of first eight months).

2.3.4. Hydro-power development

Hydropower is one of the main sources of energy in Nepal and an important economic opportunity. It accounts for nearly 90% of installed capacity and 95% of total generation of energy. The estimated hydropower potential of Nepal is 83,000 MW of which 114 projects having 45,610 MW have been identified as commercially feasible.

As of FY 2015/16, NEA has a total installed electricity generation capacity of about 689 MW, of which the hydropower capacity is 632 MW. The total installed generation capacity in Nepal is only 1,182 megawatts (MW) against a peak electricity demand of 1,320 MW in FY 2018–2019. In addition, some hydro-power projects are scheduled to be commissioned.

The country aims to strengthen hydropower development through large-scale storage projects envisaged primarily for exporting energy, medium scale projects for meeting national needs and small-scale projects for serving local communities. In this connection, four major storage projects are proposed as Indo-Nepal cooperative initiatives. These are Chisapani Karnali (10,800 MW), Pancheswor (6480 MW), Budhi Gandaki (600 MW) and the Sapta Koshi high dam (3600 MW) which in total, would provide 22,200 MW installed capacity.

2.3.5. Agriculture and Livestock

Agriculture sector has been significantly contributing to the Nepal's economy. Agriculture occupies around one third of GDP while two third of the population is dependent on agriculture as a profession. Agriculture sector had contributed 32.12% of GDP in FY 2014/15, which is estimated to drop to 31.69% in FY 2015/16 (MoF, 2016). In FY 2015/16, annual growth rate of agriculture at base prices is expected to remain at 1.14%. As such, growth rate of agriculture in the past years has not been satisfactory.

Agriculture land is second to the forest in land use category that occupies about 21% of the total land, of which only 59% of the agriculture land (1.766 million ha) is irrigable and less than one-third has round-the-year irrigation. About 40% of the arable land is still rain-fed; hence, the agriculture production is largely dependent on weather condition.

Still, agriculture constitutes a very important source of local livelihoods as well as an important sector of Nepal's economy. The contribution of agriculture sector to economic growth during the recent decade is shown in Figure 2-6.

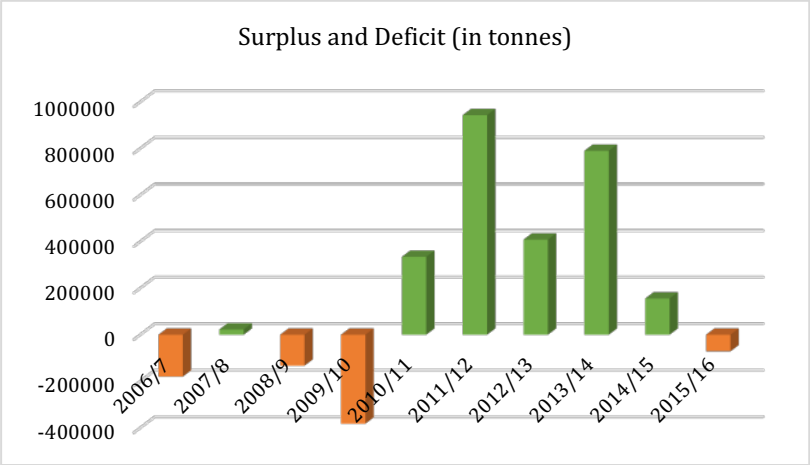
Figure 2-6: Contribution of Agriculture Sector to Economic Growth, %

Source: MoF 2020, p.67

Food security

During the ten years between FY 2006/07 to FY 2015/16, Nepal recorded a food surplus for six years and a deficit for four years (Figure 2-7). In FY 2009/10, there were 43 food deficit districts meaning that their output is unable to feed their population. Most of the food deficit districts were in the hills and mountains.

Figure 2-7: Food surplus and deficit in Nepal, 2006/07 to 2015/16.



(Source: MoAD, 2016).

2.3.6. Industry

Nepal is still at low level of industrialization. By mid-March 2020, there are a total of 8212 industries registered in Nepal – large industries 1162; medium industries 1846 and small industry 5204 (MoF 2020). In FY 2019/20, there were 277 new industries registered with proposed total capital of NRs 152.62 billion and proposing to generate 17,388 new employment. They comprise 58 large, 123 medium, and 46 small industries (DoI 2020). The industries, however, are unevenly distributed across physiographic zones and the country's seven provinces. Bagmati Province, which houses the capital city of Kathmandu, has the largest concentration of new industries registered.

2.3.7. Tourism

Nepal is a globally recognized tourism destination for its picturesque landscapes including mountains, lakes, and valleys. The country is home to Mt. Everest, the highest peak in the world.

Nepal also has a unique privilege to have several World Heritage Sites. Besides tangible heritage, its intangible heritage includes the culture -- festivals and cultural practices as well as having holy places of Hinduism and Buddhism.

Tourism is one of the main economic sectors of the country. Accordingly, over one-fifth (22%) of industries registered by mid-March of FY 2019/20 belonged to tourism sector (MoF 2020). Income from tourism sector consisted of 1.4% of GDP in 2006/06, while it was 2.5% in FY 2014/15 (MoF 2016).

2.3.8. Road and Transport

Nepal's transport sector is dominated by road transport, followed by air transport. By the end of FY 2014/15, a total of 27,496 km of roads comprising of 11,798 km black topped, 6,287 km graveled and 9,411 km earthen roads have been constructed while by mid-March of the FY 2015/16, the total length of road have reached 27,990 km comprising of 11,890 km black-topped, 6,419 graveled and 9,681 km earthen roads (MoF 2016).

By mid-March 2020, the total length of Nepal road has reached 34,347 km, including black-topped 15,254 km, graveled 9,251km, and fair-weather road 9,842km. A total of 30 international airlines are operating in Nepal. Similarly, a 56 km long railway track of 70km long Jayanagar-Janakpur-Bardibas Railway has been completed in March 2020 (MoF 2020).

Transport Vehicles

The number of registered vehicles in Nepal is currently 3.8 million (Table 2-11). Of them, motorcycles accounted for 78.8 percent, cars jeeps / vans 7.1 per cent and other vehicles 14.1 percent. Due to rapid rise of vehicles, emission from the transport sector is likely to rise, unless environmental and energy standards are enforced.

Table 2-11: Number of registered transport vehicles

Types	Up to FY 2017/18	FY 2018/19	FY 2019/20 Up to March 2020	Grand Total to Mid-March 2020
Bus	49318	3722	2083	55,123
Minibus, mini truck	25595	2409	842	28,846
Crane, dozer, excavator, truck	90411	13425	3990	107,826
Car, jeep, van	237658	23019	1095	261,772
Pickup	55973	9759	4285	70,017
Microbus	7658	2330	381	10,369
Tempo	45672	11025	5455	62,152
Motorcycle	2530722	282997	198062	3,011,781
Tractor, power tiller	143962	12220	4663	160,845
E-rickshaw	26466	8952	876	36,294
Others	7607	380	216	8,203
Total	**3,221,042**	**370,238**	**221,948**	**3,813,228**

MoF, 2020

2.3.9. Water, Sanitation and Health

In 2011, 86% of the population in Nepal had access to improved water services, up from 72% in 2001 (CBS, 2001, 2011). Similarly, the coverage of basic sanitation services almost doubled to 62% in 2011 from to 30% in 2001 (CBS, 2012). About 30% of urban households have toilets connected to sewer systems while 48% have toilets connected to septic tanks (CBS, 2012). However, most septic tanks are not designed properly. There are no systems yet for treating fecal sludge from septic tanks. The expansion in coverage of water and sanitation services over 15 years is shown in Table 2-12. This progress is remarkable. However, Nepal has to address quality of services and disparity of access to the services.

Table 2-12: Change in coverage of water supply and sanitation, 1990-2015

WASH service	Coverage in water supply and sanitation, 1990-2015 (% households)										
	1990	*1997*	*2000*	*2002*	*2005*	*2007*	*2008*	*2010*	*2011*	*2014*	*2015*
Water Supply	46	61	73	71.6	81	76.6	78.13	80.4	85.8	83.6	86.45
Sanitation	6	20	30	25	39	45.8	40.35	46.1	62	70.3	81.95

Source: MoWSS, 2016.

Health. Disease prevalence is higher in Nepal than in other South Asian countries. Millions of people are at risk of infection and thousands die every year due to communicable diseases, malnutrition and other health-related events which particularly affect the rural poor. However, some improvements in health care have been made, most notably significant progress in maternal-child health. Key health indicators are presented in Table 2-13.

Table 2-13: Key health indicators

Description	Year	Value
Infants exclusively breastfed for the first six months of life (%)	2011	70
Diphtheria tetanus toxoid and pertussis (DTP3) immunization coverage among 1-year-olds (%)	2015	91
Neonatal mortality rate (per 1000 live births)	2015	22.2
Under-five mortality rate (probability of dying by age 5 per 1000 live births)	2015	35.8
Maternal mortality ratio (per 100,000 live births)	2015	258
Life expectancy at birth (years)	2015	69.2; 67.7 (male); 70.8 (female)
Top 10 causes of death (%)	2012	Chronic obstructive pulmonary disease (9.2) Ischemic heart disease (9.2) Stroke (8.2) Lower respiratory infections (7)

Description	Year	Value
		Diarrheal diseases (3.3) Self-harm (3) Tuberculosis (3) Diabetes mellitus (2.8) Road injury (2.7) Pre-term birth complications (2.5)
Causes of death in children under 5 (%)	2013	Prematurity (19) Acute respiratory infections (15) Birth asphyxia (14) Neonatal sepsis (10) Congenital anomalies (9) Injuries (7) Diarrhea (7) Other causes (18)
Births attended by skilled health personnel (%)	2014	55.6

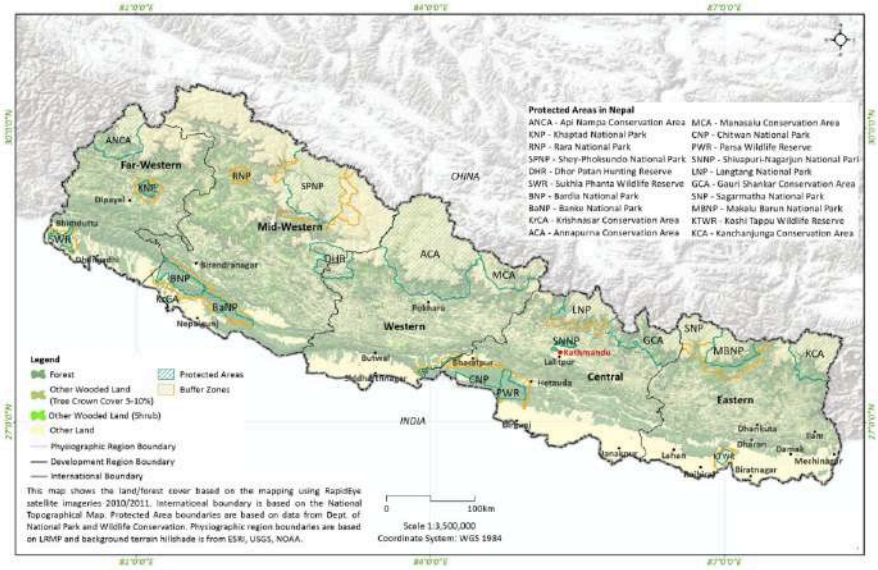
(Source: World Health Organization key indicators available at http://apps.who.int/gho/data/node.cco.ki-NPL?lang=en; Nepal: WHO statistical profile available at http://www.who.int/gho/countries/npl.pdf?ua=1).

2.4. Natural Resources

2.4.1. Forests and Biodiversity

Forests occupy 40.36% of Nepal's total land area, while shrubs cover 4.38% (Table 2-14) (MoF, 2016). Of the total 982.32 million cubic meter stem volume, Sal species (*Shorea Robusta*) occupies 19%. Likewise, total bio-mass remains at 1159.7 million tons, average stem volume stands at 165 cubic meters and average number of trees stands at 408 per hectare.

Figure 2-8: Forest Cover of Nepal (2015)



(DFRS/FRA, 2015)

Protected Areas

A total of 23.39% of total area of Nepal is covered by the conservation area under the National Park and Wildlife Conservation Act 1972. They comprise 12 National Parks, 1 wildlife reserves, 1 hunting reserve, and six conservation areas. Of this, 476 buffer zone community forests covering 138,184 ha has benefited 64587 households.

Species Conservation Plan has been prepared and the number of species of important, the populations of rare and endangered animals including those of elephant, tiger, rhino, snow leopard, crocodile and spotted-deer have been gradually rising.

Table 2-14: Forest resource statistics of Nepal

Description	Quantity
Forest area	5.962 million ha (40.36%)
Shrub area	0.648 million ha (4.38%)
Total stem volume	982.332 million cubic meters
Total bio-mass	1159.7 million ton
Average stem volume	165 cubic meter per hectare
Average number of trees	430 per hectare
Number of community forest	22415
Area of handed-over community forest	2272356 ha
Number of leasehold forest (poverty)	7846
Area of leasehold forest	45282 ha
Number protected forest	10
Area of protected forest	190809 ha
Number of partnership forest	31
Area of partnership forest	76012 ha
Number of religious forests	36
Area of religious forest	2054 ha

(Source: MoFE, 2019).

Biodiversity

Nepal is home to a rich diversity of flora and fauna due to the country's unique geography with its dramatic changes in elevation along the relatively short north-south transect and associated high variability in the physiographic and climatic conditions (MoFSC 2014b). Moreover, the country's location at the crossroads of Indo-Malayan and Palearctic bio-geographic regions has made the country a mixing place of species originating in both regions.

Nepal houses 12 of the 867 global terrestrial eco-regions. The country occupies about 0.1 percent of the global area, but harbors 3.2% of world's known flora and 1.1% of the fauna. This includes 5.2% of the world's known mammals, 9.5% birds, 5.1% gymnosperms, and 8.2% bryophytes.

There are total of 118 ecosystem types in Nepal. The natural ecosystems range from tall grasslands, wetlands and tropical and sub-tropical broadleaved forests in the Terai and adjoining Siwalik

foothills to alpine meadows above the tree line. The country's forest ecosystems can be categorized into 10 major groups, namely tropical, subtropical broadleaved, subtropical conifer, lower temperate broadleaved, lower temperate mixed broadleaved, upper temperate broadleaved, upper temperate mixed broadleaved, and temperate coniferous, subalpine, and alpine scrub. Among the rangeland ecosystems, the tropical savannas and alpine meadows are exceptionally rich in biodiversity.

Nepal's wetlands harbor many threatened species of flora and fauna, and serve as resting places for many migratory and globally threatened birds. Ten of the country's wetlands have been listed as Ramsar sites.

The country is also rich in diversity of agricultural crops, their wild relatives, and domestic animal species and varieties. Over 550 crop species are identified as having food value, and around half of those species are believed to be currently under cultivation. The country's horticultural diversity includes around 400 species and subspecies of horticultural crops, including 45 species of seasonal fruits. An estimated 200 species of vegetables, including 11 different local varieties of potatoes, are grown in the country.

A total of 312 flowering plants, 160 species of animals (including one species of mammal), one species of bird, and 14 species of herpeto-fauna are reportedly endemic to Nepal. The high-altitude rangelands are especially important from the perspective of endemism.

Many species of plants and animals, including 54 species of wild mammals and 18 species of trees found in the mountains, are threatened. Birds are among the most threatened group of fauna. Over half of Nepal's nationally threatened bird species inhabit lowland forests, and over a quarter live in wetlands. Among the known species of domestic animals, pure *siri* cattle has become extinct, *bampudke* pig (*Sus scrofa*) is under threat of extinction, and *Achhami* cattle (*Bos indicus*) and *lampuchhre* sheep (*Ovis aries*) are near endangered.

Very limited updated information exists regarding the country's genetic diversity. Nine species of plants, 55 mammals, 149 birds, 64 herpeto-fauna and 21 fish are included in the IUCN Red List. Similarly, 15 group and species of plants, 52 mammals, 108 birds and 19 reptiles and three insects have been listed in the CITES Appendices. Several species of plants and animals, including 27 mammals, nine birds, 14 angiosperms, and four gymnosperms have been declared as protected species by the government.

2.4.2. Water Resources

Nepal has more than 6000 rivers and rivulets draining from north to south towards the Ganges. Rivers in Nepal can be classified into the following three types based on their origin and discharge:

- Large snow-fed rivers originating from the Himalaya (Koshi, Gandaki, Karnali and Mahakali) with significant discharge even in dry season
- Median rivers originating from the Mahabharat Hills (Kankai, Kamala, Bagmati, West Rapti, Babai) with little flow during dry season.
- Small rivers (Biring, Ratuwa, Lohendra, Lakhadehi, Lal Bakaiya, Tinau, Khutia and many others), which are almost dry during dry season and experience flashfloods during monsoon time.

There are 33 rivers having their drainage areas exceeding 1000 km^2. The large rivers– the Saptakoshi (eastern), the Gandaki (western) the Karnali (mid-western), and the Mahakali (far-western), constitute the four major river systems of the country–all predates the uplift of the main Himalayan ranges and cut through the mountain ranges to form deep river valleys.

As the southern slopes of the Mahabharata, Himalayan range and the eastern two-third of the country receive the maximum precipitation, there is more contribution of flow from these catchments. About 74% of the total annual surface flow occurs in the four months of June – September.

About 4063 sq. km of the country is covered by surface water, of which 97.3% consists of large rivers followed by lakes (1.2%), ponds (1.2%) and reservoirs (0.3%). The area under snow and ice is 17920 km^{2}that represents 13 % of the country's total area (MoPE, 2004).

Nepal's Terai and some valleys like Kathmandu have abundant groundwater resources in the form of both artesian and non-artesian aquifers and are mainly used for drinking and irrigation purposes. But their recharging and sustainability has been a major concern in the light of climate change these days.

Snow and Glacier

According to the 2010 Glacier Inventory of Nepal (Bajracharya et al., 2010, Bajracharya and Maharjan, 2010), there are 3808 glaciers covering an area of 4212 km^2 (Table 2-15). Previous study showed a total of 3252 glaciers covering a total area of 5312 km^2 (ICIMOD, 2001). The recent increase in their number is mainly due to disintegration of large glaciers mainly due to loss of ice on those glaciers.

Table 2-15: Distribution of glaciers in the river basins of Nepal

Basin	No. of Glaciers	Total Area (sq. km)	Highest Elevation(m)*	Lowest Elevation(m)*
Koshi	843	1,180	8,437	3,962
Gandaki	1,337	1,800	8,093	3,273
Karnali	1,461	1,120	7,515	3,631
Mahakali	167	112	6,850	3,695
Total	**3,808**	**4,212**		

(Source: Bajracharya et al. (2010), Bajracharya and Maharjan (2010). Note: *above sea level)

Water availability and use

Nepal is a rich country in terms of water resources. The surface water available in the country is estimated to be about 225 billion cubic meter (BCM) per annum or equivalent to an average flow of 7125 cubic meter per second., out of which only 15 BCM per annum is in use. Around 95.9% of 15 BCM has been used for agriculture, 3.8% for domestic purpose and only about 0.3% for industry (ADB/ICIMOD, 2006; WECS, 2011). Until now, Nepal has utilized mainly medium and small rivers for different uses such as drinking water, irrigation and hydropower. The larger and perennial Himalayan rivers, except for a few run-of- the-river schemes, have been virtually left untapped.

2.4.3. Mineral Resources

Mineral deposits found so far in Nepal are often in small quantity and scattered in location, and mostly lack commercial viability. Due to limited exploration in the past, comprehensive inventory of mineral resources is still not available.

Natural gas mines of 316.0 million cubic meters have been explored in Kathmandu valley while that of 180 million MT of magnesite has been discovered in Dolakha. Similarly Iron ores deposits of about 10 Million MT are explored in Lalitpur (Fulchoki), Ramechhap (Those) and Nawalparasi (Dhauwadi); copper mines totaling about 14 million MT have been explored in Solukhumbu (Wapsa), Makwanpur (Kalitar); 14 million MT of chalk mines in Chitwan, Tanahun and Dadeldhura,Myagdi, Kaski districts; 5 million MT of coal mines in Dang, Rolpa,Palpa and Arghakhanchi, marble mines in Lalitpur, Makwanpur and Kavre districts; and gold, copper, lead and zinc deposits have been discovered in Rolpa, Baitadi, Darchula, Bajhang, Ilam districts. Likewise, mines of precious stones such as kainite, tourmaline, quartz crystals have been found in Jajarkot, Achham, Kalikot, Dailekh,Sankhuwasabha and Dhading, while dolomite, phosphorite, mica, salt deposits have been explored in other districts.

According to MoF (2016), exploration shows that cement factories can utilize a total of 1.07 billion MT of limestone from districts of Udayapur, Dhankuta, Sindhuli, Makwanpur, Lalitpur, Dhading, Syangja, Arghakhanchi, Surkhet, Dang, Salyan, Baitadi and Palpa districts as a result of departmental level studies and researches (MoF, 2016). These support 13 cement factories with capacity of 8,450 Ton/day, while 10 more factories are under construction.

2.5. Governance and Coordination Mechanisms

Through the promulgation of the Constitution of Nepal on September 20, 2015, Nepal adopted a federal, democratic, republican system of governance. It has now three-tier governance, involving the federal, provincial and local levels. It is divided into seven provinces and 753 local governments (including six Metropolitan Cities, 11 Sub-metropolitan Cities, 276 Municipalities and 460 Rural Municipalities or *Gaupalika*) distributed in a total of 77 districts.

2.5.1. Exclusive and Concurrent Jurisdictions

Each of the three tiers of government under the new federal structure have their constitutionally specified autonomous and shared jurisdictions. The constitutional arrangement will eventually reshape and partly replace some of the earlier arrangements that have been made with respect to climate change related planning and implementation.

In particular, Local Government Operation Act (2017) in its Chapter 3, Article 11 (2, J, 16) has mandated Municipalities and Rural Municipalities to adopt low carbon and environment-friendly development activities. The same act in its Chapter 3, Article 11 (4, E, 1-26) has provided Municipalities and Rural Municipalities authority to protect and manage forests (community, rural and urban, religious, leasehold and collaborative), manage buffer zone forests, promote private forests, carry out afforestation in open lands, manage forest nurseries, promote greenery at local level, adopt low carbon and environmentally friendly development activities. A good part of climate change policies and interventions are now entrusted through constitutional arrangement with

provincial and local government. The governments at all levels are formulating policies, acts, guidelines, laws and by laws.

2.5.2. Climate Change Coordination Mechanisms

Recognition of the role of different government agencies and other actors in climate change, coordination mechanisms have been set up for over a decade in Nepal. After the federalization of Nepal in 2015, it has become necessary to expand coordination mechanisms on climate change to include sub-national levels (including the provincial and local levels). These mechanisms help coordinate between different organizations, and also between different functions (functional coordination).

Coordination at the Federal Level. There are two main mechanisms for coordination at the federal level: Environmental Protection and Climate Change Management National Council (EPCCMNC) and Inter-Ministerial Climate Change Coordination Committee (IMCCCC). The EPCCMNC is established by the Environment Protection Act (2019, Article 32) and is chaired by the Prime Minister, with its members comprising four Ministers, seven Chief Ministers (of all provinces), a National Planning Commission (NPC) Member, two professors, three experts, and MOFE Secretary. It is the highest body that directs on "integrating the matters relating to the environment and climate change into the long-term policies, plans and programmes," gives "policy guidance to the Provincial and Local Levels with regard to environmental protection and climate change," and manages "economic resources for environmental protection and climate change" (Article 34(1a, 1c, 1d)). The IMCCCC, on the other hand, is established by the MOFE and chaired by its Secretary having its members comprising Joint Secretaries of 22 federal ministries, NPC, and representatives of Nepal Academy of Science and Technology (NAST), National Agriculture Research Council (NARC) and AEPC, and additional members invited at the discretion of MOFE secretary.

Coordination at subnational level. Provincial climate change coordination committee (PCCCC), comprising mainly of Province level government agencies and representatives of civil society and local governments has been established in all seven provinces to coordinate climate related activities at sub national level. The coordination committees are chaired by the secretary of the Provincial Ministry of Industries, Tourism, Forests and Environment.

These coordination mechanisms operate mostly as horizontal mechanisms. For vertical coordination, the Constitution of Nepal stipulates that the three tiers of governments will operate on the principles of "cooperation, co-existence, and coordination" and communication from the federal level to sub-national agencies happens through the OPMCM and Ministry of Federal Affairs and General Administration (MOFAGA).

Functional coordination between research, policy and practice. Coordination between functional areas—climate change research, policy-making and practice (implementation)—is very crucial. But currently, NAST, AEPC and NARC are included in the IMCCCC structure. It is advisable that a core "practice community" of small group be crafted out of the IMCCCC for more frequent technical meetings so that areas of effective coordination be harnessed. Such practice community can initially focus on

- Review and evaluation of policy and programme implementation and synthesis of its learning for the long term.
- Review and evaluation of how past research on climate change was used in policy and practice.

2.6. Climate Change Policies and Measures

2.6.1. Policy Initiatives on Climate Change

Nepal aspires to become an inclusive, equitable and prosperous middle-income country by 2030. Sustainable development will continue to be Nepal's priority agenda during the socio-economic transformation in the spirit of the new Constitution to develop a peaceful, prosperous and equitable society. However, climate change poses threats to this development aspiration. Realizing this threat, Nepal has given high priority to the issues of climate change. It has undertaken a number of policy initiatives and established institutional mechanisms to mainstream climate change into development processes and adapt to its impacts. Table 2-16 summarizes the key policy initiatives in this respect.

Table 2-16: Key policy initiatives of the Government of Nepal.

Date	Policy Highlight	Key features
1988	National Conservation Strategy 1988	Milestone in the field of climate change, which has three objectives: • Sustainable use of water, land, forest and other renewable resources, • Conservation and promotion of bio-diversity (forest and agricultural), and • Protection of eco-system
June 1992	Participated climate change business	Signed the United Nations Framework Convention on Climate Change (UNFCC) *UN Conference on Environment and Development* at Rio de Janeiro, Brazil.
1994	Instrument of ratification on climate	UNFCCC has entered into force in Nepal as per the Convention provision
2003	Sustainable Development Agenda for Nepal	Identified climate change as the Future Agenda for Action.
2004	INC Submitted to UNFCCC	Nepal submitted Initial National Communication (INC) to the UNFCCC
2005	Nepal submitted the Instrument of accession to the Kyoto Protocol to its Depository	The Protocol has entered into force in Nepal. In order to expedite Clean Development Mechanism (CDM) projects, and get benefits from them, the Government of Nepal has made the Ministry of Environment (MOE) responsible to function as the Designated National Authority.
2007	Climate change issues addressed in the Interim Constitution of Nepal	Provision of the constitution includes: • Right of every citizen to live in clean environment • Right of every citizen to food security
2009	National Strategy for Risk Management	Integrate the disaster risk reduction management from national to local level and mainstreaming into development agenda.
2009	Establishment of Climate Change Council	Highest body under the Chairmanship of the Prime Minister for high-level coordination and policy formulation in Nepal.

Date	Policy Highlight	Key features
2010	National Planning agenda	National Planning Commission initiated climate resilience planning that is expected to make development efforts climate-resilient and environment friendly.
2010	Readiness Preparation Proposal (RPP) for REDD+ Plus	To prepare vision for REDD+ strategy after 2012. Submitted by Ministry of Forest and Soil Conservation (MoFSC) to the Forest Carbon Partnership Facility (FCPF) of the World Bank.
2010	Government of Nepal endorsed National Adaptation Programme of Action (NAPA)	Assessing and prioritizing climate change vulnerabilities and identifying adaptation measures.
2010	Mountain Initiative (MI)	Nepal supports the importance of initiating the MI for implementing Article 4.8 of the Convention to address the effects of climate change on mountain people and the mountains.
2011	Climate Change Policy	Provides multiple avenues for addressing the adverse impacts of a changing climate.
Nov 2011	Government of Nepal endorsed the Local Adaptation Plan of Action (LAPA) framework	LAPA provides opportunities to implement NAPA priorities with the participation of the local communities. LAPA framework ensures that the process of integrating CC resilience into local to national planning is bottom up, inclusive, responsive and flexible.
2012	Government highlighted CC policies in Rio+20	Nepal's recent policies and programs focus on integrating climate adaptation, which is also reflected in the Rio+20 submissions.
2014	SNC submitted	Nepal submitted its Second National Communication (SNC) to UNFCCC
Sep 2015	National Adaptation Plan (NAP) Formulation	MoPE launched the NAP formulation process on 18 September 2015
Feb 2016	Nepal's INDC	Government of Nepal, Ministry of Population and Environment communicated Intended Nationally Determined Contributions (INDCs) to the UNFCCC Secretariat in February 2016
April 2016	Signing of Paris Agreement (PA)	Deputy Prime Minister and Minister for Foreign Affairs, Kamal Thapa, signed on the Paris Agreement under the UNFCCC
Oct 2016	Ratification of PA	04 October 2016, the instrument of ratification was transmitted to the Permanent Mission of Nepal to the United Nations
Oct 2016	Nepal's first NDC	Government of Nepal communicated Nepal's first Nationally Determined Contributions (NDCs) to the UNFCCC in October 2016
December 2018	Climate Change Act	A joint bench of the then Chief Justice Om Prakash Mishra and Justice Tej Bahadur KC of the Supreme Court issued ruling directing the GoN to formulate acts related to the climate change.
Feb 2019	National Forest Policy 2019 (2075 BS)	MoFE formulated National Forest Policy 2019
Feb 2019	National Climate Change Policy, 2019	MoFE formulated and issued National Climate Change Policy 2019.
July 2019	National Environment Policy 2019	MoFE formulated National Environment Policy that aims to ensure the right of citizens to live in clean and healthy environment through the control of pollution, management of waste and promotion of greenery.

Date	Policy Highlight	Key features
Oct 2019	Environment Protection Act 2019	The Government of Nepal issued Environment Protection Act 2019.
June 2020	Environment Protection Rules 2020	The GoN issued the Environment Protection Rules 2020 in order to implement the Environmental Protection Act 2019.
Dec 2020	Second Nationally Determined Contribution (NDC)	The GoN approved and Ministry of Forests and Environment communicated the second Nationally Determined Contribution (NDC) to UNFCCC.

2.6.2. Highlight of Policy Provisions

Some salient features and highlight of Nepal's policies on climate change are presented in Table 2-17.

Table 2-17. Climate change related policies in Nepal.

Policy	Focus
National Adaptation Programme of Action (NAPA), 2010	The NAPA identified nine urgent and immediate climate change adaptation priority programs related to six thematic sectors (agriculture, forest biodiversity, water resources, health, infrastructure, and disaster). The first comprehensive government response to climate change, the NAPA also specified a coordination mechanism and implementation modality for climate change adaptation programs in Nepal.
Climate Change Policy, 2011	The goal of the policy is to improve livelihoods by mitigating and adapting to the adverse impacts of climate change, adopting a low-carbon emissions socioeconomic development path, and supporting and collaborating in the spirit of the country's commitments to national and international agreements related to climate change. It has time-bound targets to address climate risks and vulnerability in the country.
National Framework for Local Adaptation Plans for Action (LAPA), 2011	The Government of Nepal developed LAPA framework, as an operational instrument to implement NAPA prioritized adaptation actions. Its goal is to integrate climate adaptation and resilience into local and national planning, and to incorporate the four guiding principles of being bottom-up, inclusive, responsive and flexible. The aim of the LAPA is to integrate climate adaptation activities into local and national development planning processes, and to make development more climate-resilient.
Climate Resilient Planning Tool, 2011	The National Planning Commission (NPC) developed a climate resilience framework to guide the country in implementing development plans. It recommends methods, tools and approaches for guiding climate-resilient planning.
Nepal Development Vision 2030 (concept paper), 2011	The concept paper developed by the NPC recognizes the need for formulating climate-resilient plans, following a low carbon economic development pathway, and equipping policy-makers and practitioners with knowledge, tools, enabling policies and sustained funding to implement climate-resilient plans in order to build a climate-resilient society and economy.
Climate Change Health Adaptation Strategies and Action Plans for	The strategies and action plans have the objectives of raising public awareness and generating evidences on the effects of climate change on health, managing risks of extreme climatic events and protecting human

Policy	Focus
Nepal (2016-2020)	health from adverse effects of climate change.
Thirteenth Periodic Plan (2014-16)	The 13th periodic plan of the Government of Nepal adopts the green development approach to mitigate the impacts of climate change.
Fourteenth Plan (2016-2018)	The 14th plan has the goal of implementing development programs by adapting to climate change. It also has a strategy to mobilize national and international sources of climate finance in the national budget and increase investment.
National Forest Policy 2019 (2075 BS)	The Policy aims to production, value addition and equitable distribution of forest products and services through the sustainable and participatory management of forests, watersheds, protected areas, biodiversity, wildlife and plants.
National Climate Change Policy, 2019	The Policy aims to contribute to socio-economic prosperity of Nepal by building climate resilient society. It has devised policies and strategies for eight sectors and four inter-thematic areas.
National Environment Policy 2019	National Environment Policy that aims to ensure the right of citizens to live in clean and healthy environment through the control of pollution, management of waste and promotion of greenery.
Environment Protection Act 2019	The Act amends and consolidates prevailing laws on environmental protection in order to protect the fundamental right of each citizen to live in a clean and healthy environment, provide the victim with compensation by the polluter for any damage, maintain balance between development and environment, and to mitigate adverse environmental impacts.
Environment Protection Rules 2020	The Rules provides detailed arrangements for the implementation of Environment Protection Act.
Fifteenth Five-Year Plan	The Plan identifies climate change as one of its cross-cutting sectors and aims to achieve climate-resilient society. It has three objectives – adopt measures for mitigation and enhancing adaptation capacity; adopt environmentally friendly, clean energy and green development; access international finance and its equitable distribution.
Second Nationally Determined Contribution (NDC) (Dec 2020)	The Second NDC communicates Nepal's vision of achieving socio-economic prosperity by building climate-resilient society and the ongoing work on long-term low GHG emission development strategy by 2021, which aims to achieve net-zero GHG emission by 2050. It has single year 2030 targets for four sectors: energy; industrial processes and product use (IPPU), agriculture, forestry and other land use (AFOLU); and waste.

2.6.3. Budget Allocation for Climate Change

Nepal received roughly USD 538.24 million in international funds, which supported adaptation activities from 2009 to 2014 (Dixit et al, 2016). The amount committed by various donors for Nepal's climate finance was USD 652.4 million from 1997 to 2014. In 2011, the government undertook a Climate Public Expenditure and Institutional Review (CPEIR) to increase understanding on climate financing mechanisms. Based on its findings, a climate change budget code (CCBC) has been developed to track climate-change related expenditure at the national and sub-national levels on a regular basis. The allocation of climate responsive budget in the national budget is given in Table 2-18. It shows that climate finance has been increasing over the years.

Table 2-18. Trends of climate change budget allocation (in NRs billion).

Budget details			Fiscal Year				
			2013/14	2014/15	2015/16	2016/17	2017/18
Total national budget			*517.24*	*618.10*	*819.46*	*1048.92*	*1278.99*
Climate budget	Highly relevant	Budget	27.74	34.98	46.36	61.85	57.73
		% of total budget	5.3	5.6	5.6	5.9	4.5
	Moderately relevant	Budget	25.73	31.36	112.98	139.76	335.62
		% of total budget	4.9	5.1	13.7	13.3	26.2
	Total climate budget		53.47	66.34	159.34	201.61	393.35
Climate budget as % of total budget (%)			10.34	10.73	19.45	19.22	30.76

Source: MoF (2017)

Government and non-government agencies are implementing climate change initiatives in different parts of Nepal. The MoFE is implementing the Nepal Climate Change Support Program (NCCSP), with funding support from the UK Government and the European Union (EU) in 14 districts of mid- and far-west Nepal. This project is under implementation with particular focus on the preparation and implementation of local level adaptation plans. There are other projects such as the Community-based Flood Risk and GLOF Risk Reduction Program, as the Global Environment Facility (GEF) implementing agency.

2.7. Post-Earthquake Reconstruction

It has been six years since the devastating earthquakes that wreak havoc in April 2015. Government had identified 32 district of the country as affected districts and had implemented a dedicated reconstruction programs for private housing, academic and heath infrastructures and archeological structures that were impacted by the earthquake through National Reconstruction Authority (NRA). During these six years, Nepal has significantly progressed onto completing the reconstruction of private and public infrastructures. Until 2020 more than 90% of private housing, 83% of school buildings, 90% of government offices, 54% of health facilities and 54% of archeological and cultural buildings has been in the process of finalizing the construction (NRA, 2020). These reconstruction efforts have generated more than 4.5 million man-days of employment and subsequently healthy growth on GDP as well. Nepal Reconstruction Authority has spent more than 350 billion NRS from the Government and development partners in the reconstruction related activities. The real expenditure is even higher as various other NGOs are also working on the reconstruction sector besides the government.

3. NATIONAL GREENHOUSE GAS INVENTORY 2011

3.1. Introduction

This chapter presents Nepal's National Greenhouse Gas (GHG) inventory for the base year 2011. It provides information on the emission and removal of following GHGs: a) direct gases - Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6); and b) indirect gases such as Carbon monoxide (CO), Nitrous oxides (NOx), Non-Methane Volatile Organic Compound (NMVOC) and Sulphur dioxide (SO_2). It also considers the emissions from international bunkers and biomass burning as memo items (for an informational purpose).

3.2. Overview of Nepal's GHG Inventories

Nepal undertook two inventories of GHGs, one each in the process of preparations for the INC and SNC. The main features and results of these Inventories are summarized below in Table 3-1.

Table 3-1. Summary Description and Results of Previous GHG Inventories.

Description	Initial National Communication	Second National Communication
Submission	Jul 2004	Dec 2014
Base year for GHG Inventory	1994/95	2000/01
Sectors covered	• Energy • Industrial processes • Forestry and land-use • Agriculture • Waste	• Energy • Industrial processes • Agriculture • Land use, Land use change and forestry • Waste • Memo items: - International bunkers - Biomass
GHGs Used	CH_4, CO_2, NO_2	Direct gases: CH_4, CO_2, NO_2 Indirect gases: NO_x, CO, NMVOC, and SO_2
Future projection	2000, 2010, 2020	2015, 2025, 2030
Results (Emissions and Removals, Gg CO_2 eq)		
a. Emissions	54,043	26,222
b. Removal	14,778	12,775
c. Net Emissions	**39,265**	**13,447**

Inventory of GHG for the Base Year 1994. Table 3-2 provides a brief result of the inventory of GHG for base year 1994/95.

Table 3-2. Nepal's GHG emission Base Year 1994/95

Greenhouse Gas Source and Sink Categories	CO_2 (Gg)		CH_4(Gg)	N_2O (Gg)
	Emission	Removal		
1. Energy	1465			
2. Industrial Processes	165			
3. Agriculture			867	29
4. Land-Use Change & Forestry	22895	-14778		
5. Waste			10	1
Total emission and Removals	24525	-14778	877	30
Net emission	**9747**		**877**	**30**

Source: MOPE, 2004.

Inventory of GHG for the Base Year 2000/01. Table 3-3 provides a brief result of the inventory of GHG for base year 2000/01.

Table 3-3. Nepal's direct and indirect GHG emissions in the base year 2000

GHG Source and Sink Categories	Direct Gases (Gg)				Indirect Gases (Gg)			
	CO_2	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	Emissions	Removal	Emission					
Total National Emissions and removals	2,894	-12,776	662	26	67	2,889	333	76
1 Energy	2,763	0	164	2	67	2,755	332	76
2 Industrial Processes	131	0	0	0			1	
3 Agriculture			466	23				
4 Land-Use Change & Forestry		-12,776	15		0	134		
5 Waste			17	1				
6 Memo items								
International Bunkers (Aviation)	162				1			
CO_2 emission from Biomass	30,294							

Source: (MOPE, 2014)

3.3. Methodological Framework for GHG Inventory

3.3.1. Methodological Framework of GHG Inventory planning, preparation and documentation

The IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) is the key document used for the estimation of emissions and removal of the GHGs from four sectors (Energy; Industrial Processes and Product Use; Agriculture, Forestry and Other Land Use; Waste). This guideline

provides methodology and approaches for GHG inventory. Furthermore, following two IPCC guidelines are considered for quality assurance.

1) IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000);
2) IPCC Good Practice Guidance for Land Use, Land-Use Change, and Forestry (IPCC, 2003);

3.3.2. Process of engagement and Implementation Framework

Figure 3-1 shows the process and structure of engagement in the conduct of the inventory. It shows how this inventory's expert team on four specific sectors engaged with themselves and with the GoN as well as other actors associated directly or indirectly with the inventory process.

Figure 3-1. Preparation of GHG Inventory

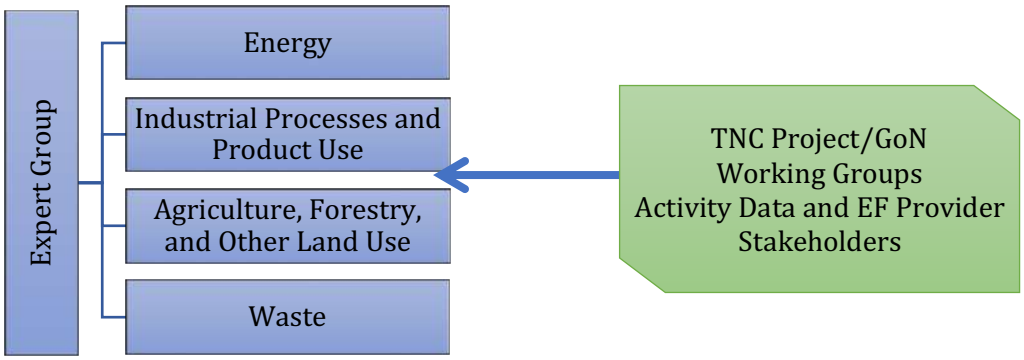
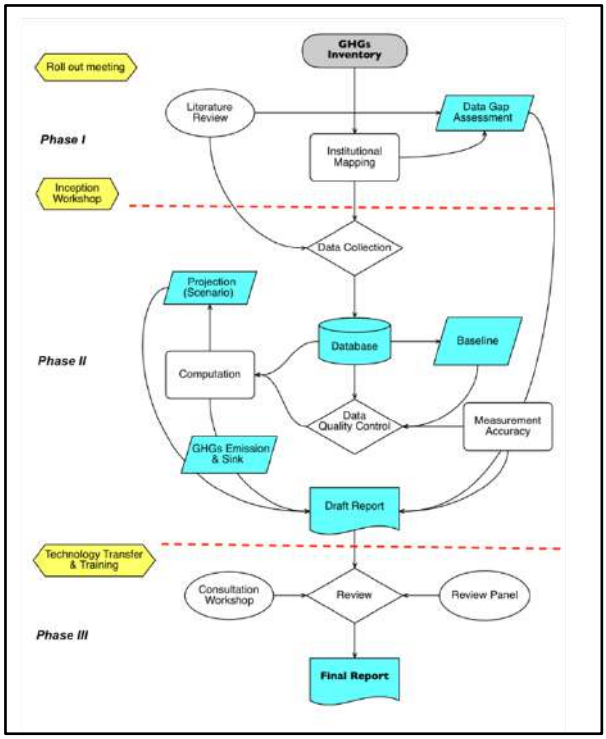


Figure 3-2 shows the three key phases of this GHG inventory and the activities undertaken in each of these phases.

Figure 3-2: Implementation Framework



3.3.3. Tiers of Estimation and Emission Factor

The emissions of GHGs are estimated by using methodologies recommended in the Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). The Good Practice Guidance (GPG) methodologies support the development of inventories that are transparent, documented, consistent overtime, complete, comparable, assessed for uncertainties, subject to quality control and quality assurance, and efficient in the use of resources. In addition, the IPCC guidelines and other documents are being updated regularly, which are closely followed and implemented in this inventory.

The general method for estimating GHG, as adopted in this inventory, is by using this formula (IPCC, 2006):

$$\boldsymbol{Emission} = \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} (\boldsymbol{EF} * \boldsymbol{Ac})_{\boldsymbol{i}} \qquad (\mathbf{1})$$

where,

EF = emission factor
Ac = activity
i = various type of activities (1, 2, 3…n).
EF is the quantity of GHG emitted per unit activity; for example, in the energy sector the amount of carbon dioxide emitted per unit of fuel consumed is an emission factor.
Ac is the activity level measured in the units appropriate for the emission factor. Activity data refers to the magnitude of human activity resulting in emissions or removals happening during given period of time.

The rigor of any emission inventory relies on the quality of its activity data, the emission coefficients and inventory methodologies used (MoSTE, 2014). In this inventory, the authenticity of data is ensured by sourcing the primary activity data for various sectors from reports of the concerned government ministries and relevant organizations and institutions.

Choice of Emission Factor and Tier Selection. Decision trees based on 2006 IPCC standard guidelines are used for methodological choice in tier selection (Box 3-1) and key category analysis to identify key source/sink category. It is always good to look for using the higher tier (Tier III), but due to lack of required data, this inventory mostly depends on Tier I and Tier II.

Box 3-1. Tiers of estimation

Tier-I approach employs activity data that is relatively coarse, such as nationally or globally available estimates of deforestation rates, agricultural production statistics, and global land cover maps.
Tier-II uses the same methodological approach as Tier 1 but applies emission factors and activity data that are defined by the country.
Tier-III approach uses higher order methods, including models and inventory measurement systems tailored to address national circumstances, repeated over time and driven by disaggregated levels.

In the first and second National communication, most of the calculations were based on the IPCC default values of emission factor. In this inventory, effort is made to incorporate more information related to national emission factor; elsewhere IPCC default parameter values are used.

3.3.4. Main Steps of Inventory

This study involved the following steps in presenting the results.

(i) Compile GHG emissions from 2011-2014 for the estimation of CO_2, N_2O, CH_4, NO_x, CO, NMVOC, SO_2 as well as for HFCs, PFCs and SF_6 using 2011 as the base year;

(ii) Conduct quality control and quality assurance of inventory data based on IPCC Good Practice Guidance, including key category analysis;

(iii) Analyze data using sectoral and reference approaches based on 2006 IPCC Guidelines on national inventories;

(iv) Establish and maintain a database for CO_2, N_2O, CH_4 and other greenhouse gases as appropriate; and

(v) Project GHG emission trends up to 2030.

3.4. Energy Sector

3.4.1. Overview

The inventory of energy sector GHG emissions comprises estimates of emissions due to combustion of fuels in stationary and mobile sources for the year 2011. The stationary sources include fuel combustion in electricity generation, manufacturing industries as well as residential, commercial and agricultural activities. Mobile sources include road transport, civil aviation and railways. This section reports the emissions of GHGs including CO_2, CH_4, and N_2O from the energy sector. The activity data and emission factors for the GHG inventory were collected from various sources and the data were categorized according to 2006 IPCC Guidelines. The data limitation was addressed by appropriate interpolation. Generally, Tier 1 method with default emission factors was considered, but in some cases, such as biomass stove combustion in residential sub sector, Tier 3 was used because of the availability of the emission factor for Nepal. Then uncertainty in the data and methods were evaluated. The trend of GHG emissions was developed by using the currently used emission factor for consistency. In addition, following the Government of Nepal's vision on energy sector (Nepal Energy Sector Vision, 2050), emissions to the year 2030 was projected for various scenarios of economic growth and policy intervention.

3.4.2. Data and Methods in the Energy Sector

The energy sector includes all fuel combustion-related emissions from energy industries, manufacturing and construction, transport and other source categories. According to the IPCC Guidelines (2006), emissions originating from energy activities (fossil fuel combustion and fugitive emissions) should be calculated for the sectors and subsectors shown in Table 3-4.

Table 3-4: GHG emissions source categories, IPCC (2006)

1 ENERGY		
1 A FUEL COMBUSTION ACTIVITIES		
1A1	**Energy Industries**	
1A2	**Manufacturing Industries and Construction**	
1A3	**Transportation**	
1A3	A	Civil Aviation
1A3	B	Road Transportation
1A3	C	Rail
1A4	**Other Sectors**	
1A4	A	Commercial/Institutional
1A4	B	Residential
1A4	C	Agricultural/Fishing
1A5	**Non-Specified**	

Memo Items
International Bunkers
International Aviation
Information Items
CO_2 from Biomass Combustion for Energy Production

The Category 1B, i.e., Fugitive Emission from solid fuels, oils and natural gas has not been included because coal mining is negligible in Nepal and other gas and petroleum mining is absent. Similarly, Category 1C, i.e., CO_2 Storage and Transport is also not included because of its irrelevance to Nepal.

The main basis of this inventory comprises data from numerous sources, including Central Bureau of Statistics (CBS), Department of Transport Management (DOTM), Water and Energy Commission Secretariat (WECS), and Nepal Oil Corporation (NOC) and also from private institutions, organizations and companies that are approved and archived by the GoN. Additional and/or missing data, required to meet the level of disaggregation for higher than the Tier I level, was sourced from both public and private institutions.

The data on petroleum products was from NOC, which was utilized to estimate the total CO_2 emissions from petroleum (fossil fuel) products. Beyond the main use of petroleum products in transportation, there is substantial use in other sectors, particularly in backup power generation. Therefore, the information of channelization of the petroleum products to different sectors should be known. Reference is also made to recent studies on the use of petroleum product in power generation and industries. The sources of data are presented in Table 3-5.

Table 3-5:List of activity data and data Source

Category	Sub-Category	Data Need	Data Source
1A Fuel Combustion Activities	1A1 Energy Industries	Amount of energy produced by power plants	Nepal Electricity Authority (NEA)
	1A2 Manufacturing Industries and Construction	Amount of Energy consumed by the industries, fuel supplied to the industries and specific fuel consumption per unit of product	CBS, NOC, WECS, Ministry of Energy, and GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit)
	1A3 Transportation	Civil Aviation	NOC
		Road Transport	DOTM, WECS
		Rail	WECS
	Other Sectors	Commercial/Institutional	Ministry of Energy, GIZ and WECS
		Residential	WECS
		Agriculture and Fishing	WECS

The guiding documents in the inventory are the *Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006), the *Revised Supplementary Methods* (IPCC, 2014). They provide guidance on the use of 'tier'. The methods for estimating emissions and/or removals are distinguished between the tiers as follows:

- Tier 1 methods apply IPCC default emission factors and use IPCC default models
- Tier 2 methods apply country-specific emission factors and use IPCC default models
- Tier 3 methods apply country-specific emission factors and use country-specific models.

This inventory was based on both Top-Down Approach (Reference Approach) and Bottom-Up Approach (Sectorial Approach), using the IPCC Tier 1 framework and default values for conversion and emission factors.

Top-Down Approach

This approach uses the data of country's energy supply to estimate the CO_2 emissions from combustion of fossil fuels. For this, data from Nepal Oil Corporation (NOC), which is the sole entity responsible for the import and distribution of all petroleum products in the country, except for fuel oil (FO), is used. The main fossil fuels imported in Nepal are petrol (gasoline), diesel, kerosene, air turbine fuel (ATF), FO, low speed diesel (in a very small amount), and liquefied petroleum gas (LPG). Various industries and businesses also import coal to be used mainly in brick kilns and cement industries. The Central Bureau of Statistics (CBS) provided the data of coal imports. In this case, since the amount of coal combustion is not known, the value of coal import is used to calculate the emissions using the reference approach.

Bottom-Up Approach

In the bottom-up approach, all of the selected data sources identified were the major energy-consuming sectors, including industries and commercial institutions. Nepal does not have comprehensive database on the fuel consumption by all the sources in various sectors. Fuel consumption in each sector was identified along with the fuel types. Relevant sectors were identified according to the IPCC 2006 Guidelines, but strictly adherence was challenging as the sectors in the guidelines might not be relevant for Nepal. On the other hand, Nepal has some industries including brick and cement, which have large contribution to GHGs emissions. These are specifically included in the list. The consumption of fuel was estimated either from the energy statistics provided by Central Bureau of Statistics (CBS) or from the report on energy consumption pattern of the selected sectors and subsectors or from Nepal Oil Corporation (NOC) sales data, whichever appropriate.

While preparing the inventory, only direct GHGs, namely CO_2, CH_4, and N_2O from key sources were prioritized. Indirect GHGs including CO, NOx, NMVOC, and SOx were excluded because of unavailability of detailed data and information, for instance, on vehicular fleet plying on the street, vehicle age, engine size, emission control technology, fuel used, vehicle kilometer travelled. This is further complicated because of tempering or malfunctioning of emission control systems, fuel adulteration or poor fuel quality, or overloading and poor maintenance of vehicles.

Energy Resources and Fuel Consumption in Nepal

Nepal's energy consumption per capita is low, one-third of the Asian average and less than one-fifth of the world average. In 2008-2009 total energy consumption of the country was 401,000 TJ. However, it has higher energy consumption with respect to its gross domestic product (GDP). The annual average growth of energy consumption is 2.4% (WECS, 2010). A comparison of energy share by various sources is given in Table 3-6. It shows that fuelwood has the largest share in energy consumption. During 2008-2009 fuelwood comprised about 78% of primary energy consumption, whereas other biomass sources, viz, agricultural residue and animal dung comprised 4% and 6%

respectively. Similarly, petroleum fuels comprised about 8% and electricity was only about 2% of total energy supply of the country.

Table 3-6: Primary energy shares in Nepal

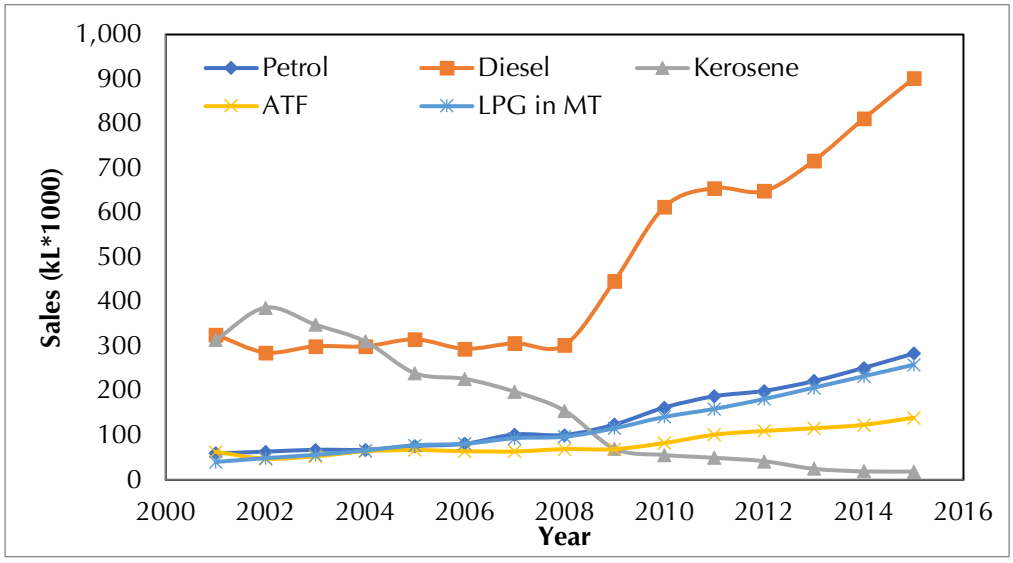
Fuel Type	Energy, '000 GJ *(% share)*	
	Year 2008-09	Year 2011-12
Fuel wood	311,577 *(77.7)*	267,400 *(71.1)*
Agriculture residue	14,837 *(3.7)*	13,200 *(3.5)*
Animal dung	22,857 *(5.7)*	19,100*(5.1)*
Petroleum	32,882 *(8.2)*	46,200 *(12.3)*
Coal	7,619 *(1.9)*	14,800 *(3.9)*
Renewable and others	2,406 *(0.6)*	50,00 *(1.3)*
Electricity	8,020 *(2)*	10,600 *(2.8)*

Source: WECS, 2010; WECS, 2014.

This has somewhat changed in the recent years. The data of 2011-2012 indicates slight increase in the dependency on fossil fuel while decrease in the biomass consumption for primary energy resource. The share of fuelwood in primary energy has dropped from 78% to 71% during 2008/09 to 2011/12. During the same period, the consumption of petroleum products increased by half while that of coal doubled.

The data from Nepal Oil Corporation shows a sharp rise in the sale of petroleum product in recent years (Figure 3-3). This can probably be attributed to increase in economic activities after the beginning of peace process in 2007 and to power shortages which led to widespread use of diesel for electric power generation. The consumption of diesel increased drastically from year 2008/09. Except for kerosene, which has been replaced by LPG for cooking and electricity for lighting, the consumption of all the other fossil fuels has increased significantly.

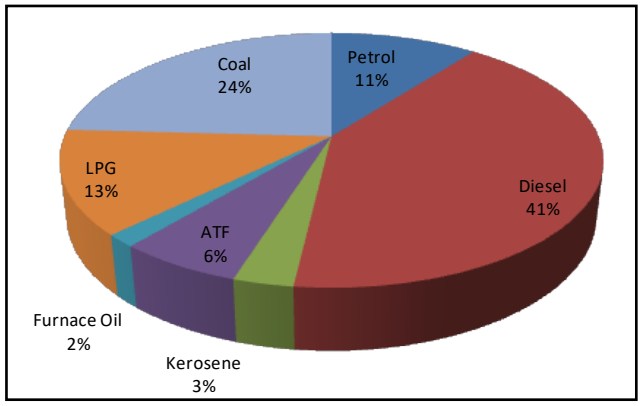
Figure 3-3: Sales of petroleum products in Nepal



Note: ATF: aviation turbine fuel; Source: NOC (2016).

Figure 3-4 shows the share of energy from fossil fuel in the year 2010/11. Diesel fuel has the largest energy share followed by coal, and petrol. Diesel is used in transportation, power generation, and thermal energy generation in industries. Coal is mostly used by cement and brick industries, that consume high amount of thermal energy.

Figure 3-4: Share of energy from fossil fuel in Nepal, 2010/11



Issues Pertaining to Estimation of GHG Emissions

a. Information on Sector-wise Fuel Consumption

In order to compute the GHG emissions from fuel combustion activities, information on fuel consumption in use sectors and sub-sectors is needed. But NOC provides data of the sale of the petroleum products; the fuel consumption in all the use sectors is not known. This becomes particularly challenging for diesel, which comprises highest share of fossil fuel and is used in industries, agriculture, and power production. Similarly, some LPG is used in transportation and some in commercial sector. Most of petrol (gasoline), however, is consumed in transportation and only a small portion in commercial sector, agriculture and industries. So, reference is made to the available information related to energy consumption in industries, transportation and commercial sectors. Appropriate interpolation technique was used for missing data.

All the petroleum fuel, except for fuel oil (FO), imported and sold in Nepal is the sole responsibility of NOC. Some private companies also import and supply of FO to certain industries, but it is difficult to calculate its exact amount. The amount of FO was estimated on the basis of data on thermal energy consumption by various industries.

b. Use of Biomass in Industries and Other Sectors

Most of thermal energy requirement of residential, industrial, commercial sector in Nepal is met from biomass sources. In this inventory CO_2emission from biomass in all these sectors is computed but neither added nor compared with the emissions from other fuels, assuming that emission from biomass combustion was neutralized through regeneration. Thus, CO_2 emission has been reported as Information Item. However, the non-CO_2 emissions from biomass combustion (CH_4 and N_2O) have been incorporated and added in this inventory.

3.4.3. GHG Emission from Energy Sector

Nepal's Energy Sector emitted 14,703 Gg CO_2-eq of GHGs in the base year 2011. The various contributors to these emissions are presented in Table 3-7. This table and Figure 3-5 (a) show that manufacturing industries are the largest contributor to CO_2 emission followed by Transport and Other sectors. The contribution of energy industries is the lowest. However, in terms of emission of all GHGs, the Other Sector has the largest contribution (Figure 3-5 (b)). 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. The CO_2 emission from biomass combustion for energy (23,499 Gg) is also significant. however, it is not reported in the national emission.

Figure 3-5: Share of Emissions by Energy Sectors 2011: (a) CO_2, and (b) GHG (CO_2-eq)

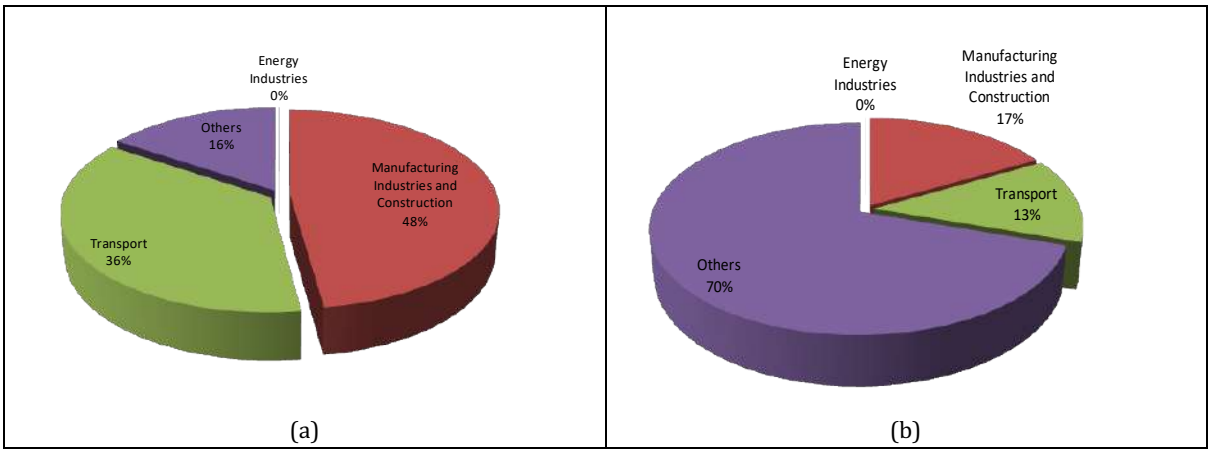


Table 3-7: Summary of GHG emissions from Energy Sector for 2011.

EMISSION SUMMARY					
Categories		**CO2**	**CH4**	**N20**	**CO2eq**
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 Gigagram)		**4678.20**	**354.91**	**4.03**	**14751.67**

Categories		**CO2**	**CH4**	**N2O**	**CO2eq**
Memo ITMES			**Tonnes**		**Gg**
	International Bunker	172,507.58	1.21	4.83	173.98

Categories	**CO2**	**CH4**	**N2O**	**CO2eq**
INFORMATION ITEMS	**Gg**			
CO2 from Biomass Combustion for Energy Production (Gg)	23,499			

The GHG emission by various sub-sectors within the Energy Sector is presented in Table 3-8. Each subsector is discussed in subsequent sections.

Table 3-8: Energy Sector GHG emissions inventory for 2011

Categories		CO2	CH4	N2O	CO2eq
1 Energy		**Tonnes**			**Gg**
1A	**Fuel Combustion Activities**				
1A1	**Energy Industries**	**2376.07**	**0.09**	**0.02**	**2.38**
1A1a	Electricity Production	2376.07	0.09	0.02	2.38
1A2	**Manufacturing Industries and Construction**	**2237336.50**	**39.40**	**60.06**	**2256.22**
1A2a	Iron and Steel	78596.67	2.34	0.83	78.90
1A2b	Soap and Chemicals	6017.50	0.24	0.05	6.04
1A2c	Cement	390937.99	4.97	5.98	392.84
1A2d	Brick	1485912.94	16.52	23.35	1493.28
1A2e	Pulp and Paper	3159.22	0.13	0.03	3.17
1A2f	Food and Beverages	272712.20	11.00	2.20	273.64
	Non-CO2 emissions from biomass combustion in industries		4.20	27.62	8.34
1A3	**Transport**	**1708915.97**	**274.02**	**79.72**	**1739.52**
1A3a	Civil Aviation				
1A3ai	International Aviation	172507.58	1.21	4.83	173.98
1A3aii	Domestic Aviation	83059.02	0.58	2.32	83.76
1A3b	Road Transport				0.00
1A3bi	Bus	309838.79	16.83	16.83	315.27
1A3bii	Minibus/Microbus	148826.13	7.83	7.83	151.36
1A3biii	Truck/Tanker/Lorry	489365.55	26.28	21.47	496.42
1A3biv	Car/Jeep/Van/Pickup	489596.29	141.00	21.87	499.64
1A3v	Three Wheelers	30488.55	14.89	0.92	31.13
1A3bvi	Tractors/Other	24658.25	1.82	1.82	25.25
1A3bvii	Two Wheelers	125767.73	64.40	6.27	129.25
1A3bviii	Train	7315.66	0.39	0.39	7.44
1A4	**Others**	**729575.71**	**354593.88**	**3889.65**	**10753.54**
1A4a	Commercial/Institutional	129295.52	4.92	0.99	129.71
1A4b	Residential	300742.38	5.60	0.69	301.09
1A4c	Agriculture	299537.81	12.14	2.43	300.57
	Non-CO2 emissions from biomass combustion in other sector		354571.22	3885.54	10022.17

MEMO ITEMS					
	International Bunker	172,507.58	1.21	4.83	173.98
	Biomass Combustion	23,499,076			

Energy Production

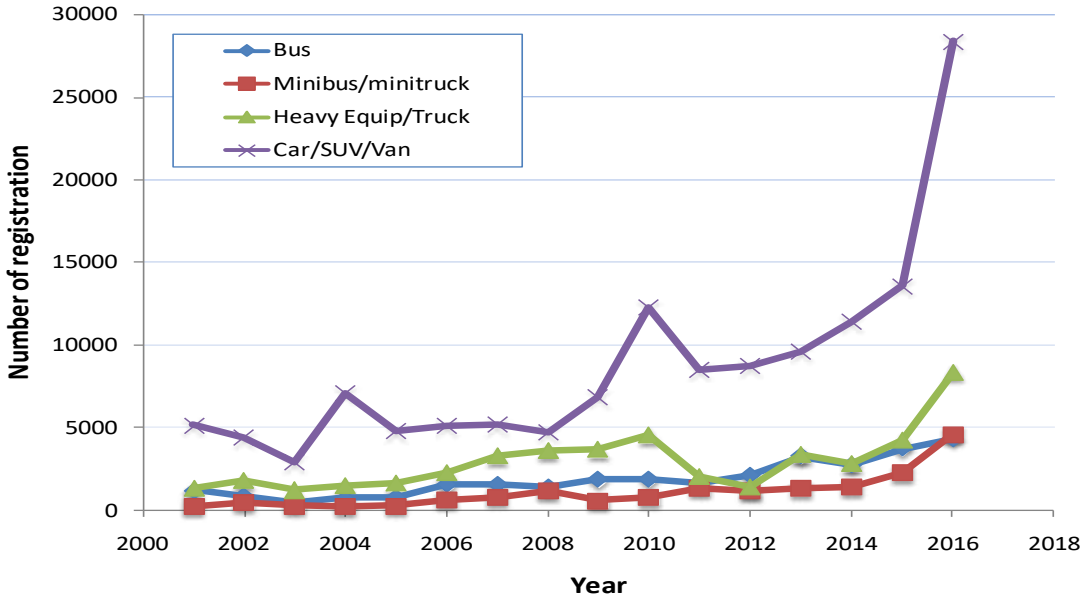
Emissions from the energy industries include those from fossil fuel combustion for electricity generation and solid fuel manufacturing. The later source is not significant in case of Nepal. There are two major fossil fuel-based power plants owned by Nepal Electricity Authority: Bansbari Multifuel Power Plant (39 MW) and Hetauda Diesel Power Plant (14.5 MW). These plants are used during peak load hours. In 2010/2011, Bansbari and Hetauda plants generated 2348 and 1333 MWh of electricity, respectively. They emitted 2.38 Gg CO_2-eq, less than one percent of GHG emission from Energy Sector.

Apart from these power plants, diesel generators were used by Manufacturing Industries and Other Sectors for back-up electricity as the country facing a significant power deficit (6-12 hours of power cuts daily). The contribution of GHGs from power generation is reported in the Manufacturing Industries sub sectors.

Transportation Sector

Transportation sector in Nepal has grown significantly in recent decades. Figure 3-6 shows the trend of yearly vehicle registration since 2000/01. Road transportation is predominant mode of transport and accounts for 90% of the movement of passengers and goods.

Figure 3-6: Vehicle registration trend in Nepal from 2000/01



Source: www.dotm.gov.np.

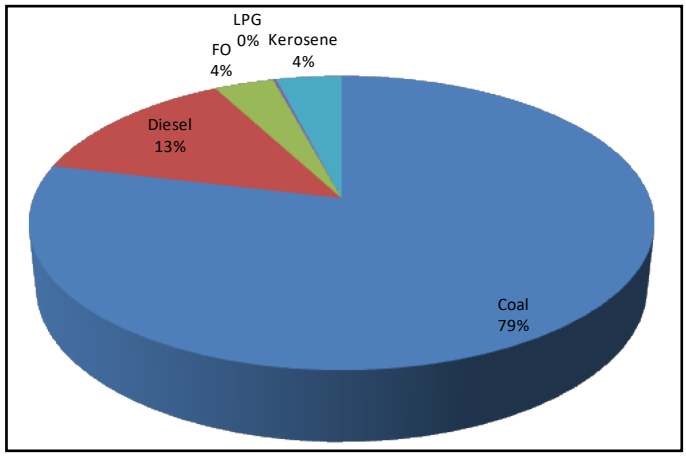
Diesel is the main fuel consumed in the transportation sector, followed by petrol and LPG. Transportation consumes about 68% of diesel and emits 1,741 Gg of CO_2-eq, which is 37% of the total GHG emission.

Manufacturing Industries and Construction

Industrial sector in Nepal comprises brick, cement and metal manufacturing along with food and beverage industries. They use both thermal and electrical energy. They use biomass, coal, and fuel oil for thermal energy. Coal, fuelwood and diesel contribute respectively 46.24%, 24%, and 15% of

total energy used in the Industrial sector; the share from all of them is higher than that from electricity (13.6%) (WECS, 2014). A small amount of kerosene and LPG is also used. Diesel is basically used for captive electricity generation because of severe power shortage. Among the total energy required in industry, 10% is for backup electrical power generation and rest is for thermal energy. In this inventory, the emission from fuelwood used by various categories of industries in not compared due to unavailability of reliable data on its use in the industries. However, the total energy from fuelwood to the industrial sector is available and has been mentioned as Information Item. Non-CO_2 emissions have been included in the inventory. Figure 3-7 compares the share of fuel type (fossil fuel-based) in this sector in the year 2011.

Figure 3-7: Share of fossil fuels in Manufacturing Industries and Construction



Manufacturing Industries emit 2,248 Gg of CO_2e. It is the largest contributor of CO_2 (48%) under Energy Sector; when total GHG is compared, it is the second largest contributor (17%). In this case construction sector is not included because of unavailability of proper data on the status of heavy equipment and construction machineries operation. A separate survey has to be carried out in this regard.

Brick industries are the largest contributor to CO_2 emission in this sector with 1493 Gg of CO_2 (66%) followed by cement industries (18%), food and beverages (12%) and metal (4%). Soap and Chemical and Pulp & Paper industries have the lowest contribution, both of which are less than 1%.

Other Sectors

Other Sectors includes Residential, Commercial and Agricultural subsectors. Total GHG emission from this sector is 729 Gg of CO_2, which is 16% of the total CO_2 emissions due to Fuel Combustion Activities. In terms of total GHG emissions, this sector has the largest contribution with 9,328 Gg CO_2-eq (70% of the total GHG emissions) as this sector emits large amount of CH_4 and N_2O as a result of biomass combustion.

Residential Subsector: Nepal's Residential Subsector depends primarily on biomass for its primary energy need for cooking and heating. Due to rapid urbanization, there has been shift from biomass towards fossil fuel. In recent years the rate of biomass consumption is slowing down and

being compensated by LPG. This subsector emits 301 Gg of CO_2. The emission from biomass (fuel wood) is not included here and it is reported as Information Items.

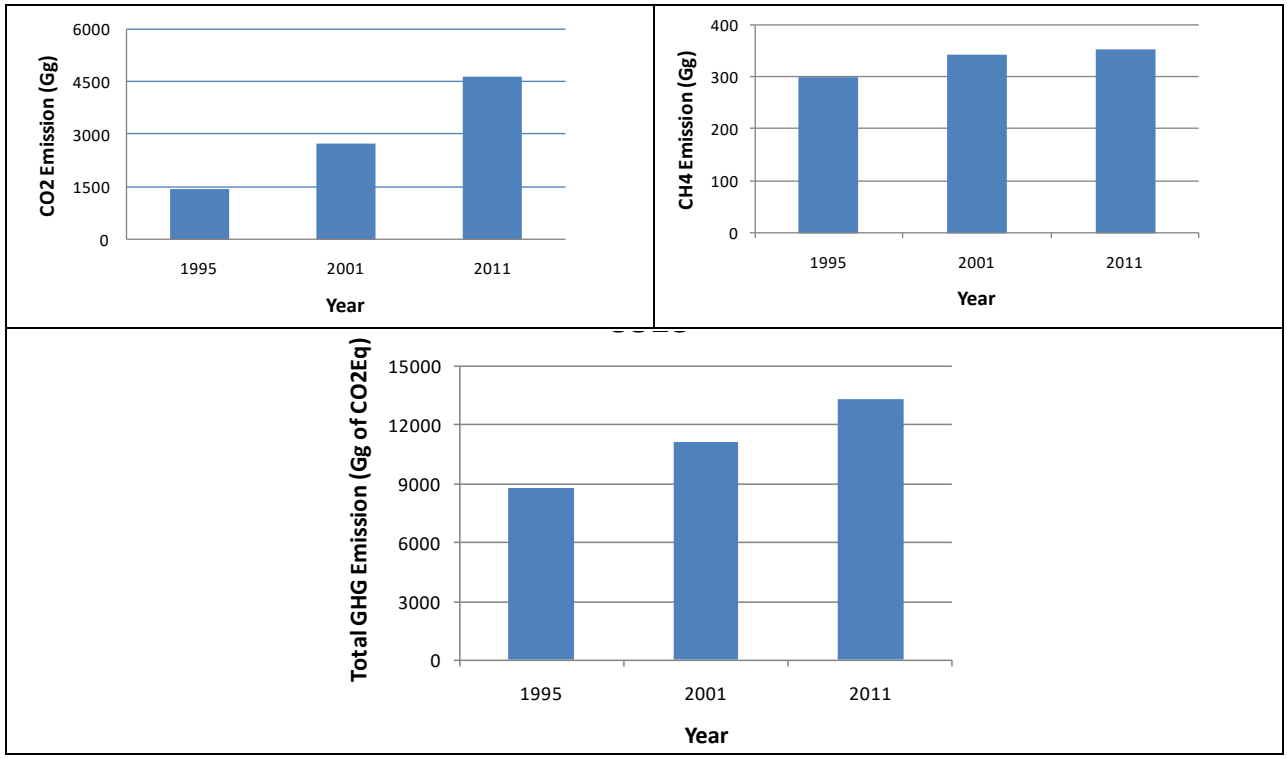
Hotel Subsector: Hotels use fuels including coal, diesel and LPG for heating, and diesel and kerosene for backup electric power. In total, this subsector emits129.7 Gg of CO_2.

Agriculture Subsector: Most of the agriculture activities in Nepal are carried out in traditional way. However, in recent years, the mechanization is increasing for tillage and threshing. Diesel is the major fuel used (95% of the total energy input). This subsector emits 300 Gg CO_2.

3.4.4. Trends in GHG Emissions

A comparison has been made with regard to GHG emissions since the INC. In order to have consistent data for comparison, the energy consumption scenario in the INC and SNC has been combined with the emission factors that have been used in this report. Figure 3-8 shows comparison of CO_2, CH_4 and total GHG (CO_2-eq).

Figure 3-8: CO_2, CH_4, and Total GHG emissions in reference years



CO_2 emission has been increasing sharply over the years, as the consumption of fossil fuel is increasing. The emission mentioned here is only the result of fossil fuel combustion. The non-CO_2 emissions, however, do not match with the trend of CO_2 emission. Most of CH_4 and N_2O emissions are due to the biomass combustion, but its consumption has not increased as rapidly as fossil fuels. In fact, in recent years, the rate of increment in biomass consumption is gradually slowing down.

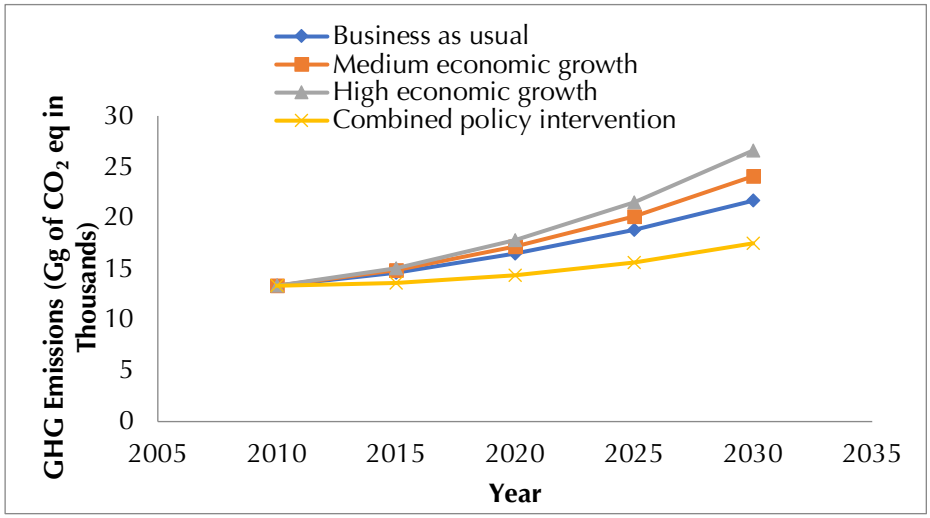
3.4.5. GHG Emission Projection

The total energy consumption in 2010/11 is estimated to be 376.3 million GJ, dominated by traditional sources such as fuelwood, agricultural residue and animal waste. For the projection of GHG emission, following scenarios, according to Nepal Energy Sector Vision 2050, have been considered:

- *Business- as-Usual (BAU):* GDP growth rate according to low growth case (average growth rate of 4.4%); energy mix in the future considered invariant vis-à-vis the base year.
- *Medium Growth Scenario:* GDP growth rate according to Base case (average growth rate of 5.6%); energy mix in the future considered invariant vis-à-vis the base year.
- *High Growth Scenario:* GDP growth rate according to high growth case (average growth rate of 6.5%); energy mix in the future considered invariant vis-à-vis the base year.
- *Combined Policy Intervention Scenario:* GDP growth rate of 5.6%. Few interventions that have been considered are:
  - Replacement of traditional and fossil fuels by clean energy alternatives – electricity, LPG, and ICS.
  - Promotion of electrification in all five sub-sectors for lighting, heating and other purposes.
  - Intervention through more efficient process technologies in industries
  - Intervention through mass transportation systems
  - Introduction of new electric and bio-fuel transportation technologies

The LEAP Software was used to estimate the projected energy demand and corresponding emissions for these scenarios. The projection shows that GHG emissions can be significantly reduced with combined policy interventions (Figure 3-9).

Figure 3-9: Total GHG emissions projection under various scenarios.



3.5. Industrial Processes and Product Use

3.5.1. Brief summary

Industrial Processes and Product Use (IPPU) comprises another sector from which Nepal's GHG emission is computed. For this inventory, activity data and emission factors were collected from various sources and were categorized according to 2006 IPCC Guideline. The data and their quality were extensively checked and documented, and related uncertainty in data and methods were evaluated. Accordingly, GHG emission is estimated from appropriate tier-based methods and its trend and projections are developed. The emission of indirect GHGs is also computed in the same manner.

3.5.2. Overview of the IPPU Sector

The GHG emissions from IPPU contribute the least to Nepal's GHG emission (MoPE, 2004; MoSTE, 2014). Nepal has very small share of manufacturing value addition in its GDP. But GHG emission from IPPU sector is gradually increasing over the past several years. This has to do with the gradual recovery in Nepal's manufacturing sector (CBS 2014a), which results in greater industrial GHG emissions (Sanchez and Stern, 2016).

For calculating emissions in IPPU sector, the IPCC (2006) Guidelines suggests the following categories:

- Mineral industry
- Chemical industry
- Metal industry
- Non-Energy products from fuels and solvent use (lubricant use, paraffin waxes, solvent, etc.)
- Electronics industry
- Emissions of fluorinated substitutes for ozone depleting substances
- Other product manufacture and use (electrical equipment, N_2O from product uses in medical applications, etc.)
- Others (pulp and paper, food and beverages, etc.)

In Nepal's IPPU sector, mineral production sub-sector has the highest GHG emission, mainly comprising CO_2 emission from cement production. There were 35 cement industries in Nepal in 2012 (NEEP, 2012), and they are growing in number and production capacity. In cement manufacturing, CO_2 is emitted during clinker production as follows:

$$\textbf{Limestone } \mathbf{CaCO_3} \textbf{ + heat} \rightarrow \mathbf{CaO + CO_2}.$$

Other emissions comprise SO_2 from cement production; NMVOC from food and drink industries; NO_x, NMVOC, CO and SO_2 from paper industries; and Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and Sulphur hexafluoride (SF_6). HFCs and PFCs, which serve as alternatives to ozone depleting substances (ODS), are not produced in Nepal, but only consumed in purposes such as refrigeration or other uses. The Montreal Protocol does not control HFCs and PFCs as they do not

contribute to depletion of the stratospheric ozone layer. However, they have high global warming potentials (GWPs) and long atmospheric residence times.

The category of non-energy products from fuels and solvent use includes emissions from the first use of fossil fuels as a product for primary purposes other than combustion for energy and use as feedstock or reducing agent. The category includes lubricants, paraffin waxes, bitumen/asphalt, and solvents, of which the first two are covered in this assessment. Lubricants are mostly used in industry and transportation, and comprise (a) motor oils and industrial oils, and (b) greases. In this inventory, CO2 emission is calculated by assuming that the amount of lubricants used was fully combusted. Nepal does not have lubricant-producing industries, hence the import data from the Department of Customs (DoC, 2012) and other annual reports, was used. Similarly, paraffin wax category includes such products as petroleum jelly, paraffin waxes and other waxes. Paraffin waxes are separated from crude oil during the production of light (distillate) lubricating oils. Paraffin waxes are categorized by oil content and the amount of refinement.

3.5.3. Data and Methods

Table 3-9 provides the categories of data and the corresponding sources for estimating the greenhouse gas emissions from IPPU sector in Nepal.

Methodology

The IPCC (2006) guideline has been used to estimate the GHG emissions. Cement production is the major category in the IPPU sector, for which Tier 2 is the preferred method. It is used where the clinker production data are available. Otherwise, Tier 1 method has been employed. For other categories, the Tier 1 method has been used with the combination of mass balance approach and emission-factor approach.

i) Choice of Emission Factors

Most of the emission factors have been obtained from the IPCC emission database and European Monitoring and Evaluation Program/European Environment Agency emission (EMEP-EEA) database (Table 3-10). These sources of emission factors are used throughout the estimation since national emission factors for Nepal are not available.

Emission Factors for Cement Production

Tier 1 Method: Use a default CaO content for clinker of 65 percent (IPCC, 2006)

EF_{clc} = 0.51 • 1.02 (CKD correction) =0.52 tonnes CO_2/tonne clinker

EF_{clc}: emission factor for clinker in the particular cement, tonnes CO_2 /tonne clinker

CKD: Cement kiln dust

Table 3-9: Overview of IPPU categories, activities, and data sources

Category	Subcategory	GHG	Required data	Method	Data Sources
2A. Mineral Industry	2A1 Cement Production	CO_2, SO_2	Clinker production data, cement production data, national import and export data of clinker and cement	T1 & T2	CBS (2014b), DoC (2012) and other annual reports, DoI-Nepal (2011) and other annual reports, MoF (2011) and other annual reports, MoSTE (2014), NEEP (2012), TEPC (2017), UCIL (2016), USGS (2016)
	2A2 Lime Production	CO_2	Lime production data	T1	No data for base year
2C. Metal Industry	2C1 Iron and Steel Production	NMVOC, NO_x, SO_2, CO	National iron and steel production data	T1	MoF (2011) and other annual reports
2D. Non-Energy Products from Fuels and solvent Use	2D1 Lubricant Use	CO_2	National data for non-energy uses of lubricants, motor oils and greases in transportation and industries	T1	DoC (2012) and other annual reports, TEPC (2017)
	2D2 Paraffin Wax Use	CO_2	National data for non-energy uses of paraffin waxes	T1	DoC (2012) and other annual reports, TEPC (2017)
2F. Product Uses as Substitutes for Ozone Depleting Substances	2F1 Refrigeration and Air conditioning	HFCs	National import data of refrigerants	T1	MOPE (2017)
2G. Other Product Manufacture and Use	2G3 N_2O from product uses	N_2O	National import data of nitrous oxide cylinders	T1	DoC-India (2017)
2H. Other	2H1 Pulp and Paper Industry	NMVOC	National paper production data	T1	MoF (2011) and other annual reports, NEEP (2012)
	2H2 Food and Beverages Industry	NMVOC	National food and beverage production data	T1	MoF (2011) and other annual reports, NEEP (2012)

Notes:

a) The categories are classified according to IPCC (2006) guideline.

b) T1, T2 and T3 are tier 1, tier 2 and tier 3 methods of IPCC (2006) guideline.

c) Past lime production data is available from USGS. But it is available only up to 2003.

Table 3-10: IPPU's subcategories and emission computation

Category	Emission factor				Data source
Iron and steel	**g NO_x / tonne of produced steel**	**g NMVOC/tonne of produced steel**	**g CO/tonne of produced steel**	**g SO_2/tonne of produced steel**	
Iron and steel (rolling mills)	40	30	1	45	IPCC-EFDB (2007)
Food	**kg NMVOCs/tonne food production**				
Margarine and solid cooking fats	10				EMEP-EEA (2016)
Cakes, biscuits and breakfast cereals	1				EMEP-EEA (2016)
Sugar	10				EMEP-EEA (2016)
Animal feed	1				EMEP-EEA (2016)
Beverage	**kg NMVOCs/hL beverage production**				
Beer	0.035				EMEP-EEA (2016)
Spirit, vodka	15				EMEP-EEA (2016)
Paper and pulp	**kg NMVOCs/tonne dried pulp**				
Paper and pulp	3.7				EMEP-EEA (2016)

Tier 2 Method: Estimate emissions from lost CKD based on a default value of 1.02*(IPCC, 2006).*

Box 3-2: Tier 1 and Tier 2 Method for Estimating CO2 Emissions from Cement Production

A. Tier 1 Method for Estimating CO_2 Emissions of Cement Production

In Tier 1 Method, CO_2 emission is estimated indirectly, as follows:

$$CO_2 \text{ Emissions} = [\sum i(Mci * Ccli) - Im + Ex] * EFclc$$

Where,

CO_2 Emissions: emissions of CO_2 from cement production, tonnes;

Mci:	weight (mass) of cement produced of type *i*, tonnes;
$Ccli$:	clinker fraction of cement of type *i*, fraction;
Im:	imports for consumption of clinker, tonnes;
Ex:	exports of clinker, tonnes;
$EFclc$:	emission factor for clinker in particular cement, tonnes CO_2 /tonne clinker

B. Tier 2 Method for Estimating CO_2 Emissions of Cement Production

In Tier 2 method, CO_2 emission is estimated directly from clinker production data:

$$CO_2 \text{ Emissions} = Mcl * EFcl * CFckd$$

Where,

CO_2 Emissions:	emissions of CO_2 from cement production, tonnes;
Mcl :	weight (mass) of clinker produced, tonnes;
$CFckd$:	emission correction factor for CKD (cement kiln dust), dimensionless;
$EFcl$:	emission factor for clinker, tonnes CO_2 /tonne clinker

If a significant fraction of CaO in a cement plant is coming from a non-carbonate source (e.g., fly ash), then this component of CaO is first subtracted as per the IPCC (2006) guideline.

ii) Key Categories

All data sources, including Nepal's INC and SNC reports, show that cement production is the major process that contributes to the GHG emissions in IPPU sector. Hence cement production is the obvious choice for the key category.

iii) Activity datasets

The activity datasets are obtained from the data sources given in Table 3-11. NEEP (2012) dataset was found the most reliable source of activity data because it contains the cement production data for the base year of 2011 from all the limestone-based industries. NEEP surveyed all the 8 limestone-based industries and 18 clinker-based cement industries. If limestone-based industry data are used, it is not necessary to remove the imported clinker from the production. In the clinker-based industries, the clinker is imported and hence, the GHG emission during such clinker formation outside Nepal has to be deducted from the cement production in Nepal.

CBS (2014b) data is available for fiscal year 2011-2012 and it has been used to validate the cement production data from other sources. Import and export data was taken from Customs Datasheet and TEPC (2017). The longest record of national cement production is provided by the Economic Survey (MoF, 2011 and other annual Economic Survey Reports). But the

comparison with other datasets shows significant underestimation of cement production. Hence, the method used in Second National Communication (MoSTE, 2014) has been used to estimate GHG emissions from the cement industries by using only the cement production data. Since the imported clinker is not considered in this method, the real GHG emission may be still lower than the calculated values. The USGS (2016) data is also used to compare the production of cement with global datasets. Several USGS annual reports have different revised cement production data for Nepal and the continuous increase in cement production is clearly visible from 2009 onwards in the dataset.

Table 3-11:Cement production from different data sources

Year	Cement production (tonnes)			
	From limestone–based industries	From all industries		
	NEEP	CBS	MoF	USGS
1987–1988			215010	
1988–1989			217666	
1989–1990			101179	
1990–1991			135897	
1991–1992			237327	
1992–1993			247891	
1993–1994			315514	
1994–1995			326839	
1995–1996			309466	
1996–1997			226681	
1997–1998			139080	
1998–1999			190588	
1999–2000			205835	
2000–2001			215098	
2001–2002			233000	
2002–2003			310589	
2003–2004			279412	
2004–2005			610044	
2005–2006			613643	300000
2006–2007			644325	295000
2007–2008			71132	295000
2008–2009			71000	295000
2009–2010	604480		72100	1360000
2010–2011	709003		84130	2200000
2011–2012		1627072	92543	2700000
2012–2013			86654	3000000

Note: NEEP: Nepal Energy Efficiency Programme (NEEP, 2012); CBS: Central Bureau of Statistics (CBS, 2014b); MoF: Ministry of Finance, Nepal (MoF, 2011) and other annual reports; USGS: U.S. Geological Survey (USGS, 2016)

Table 3-12 shows the iron and steel activity data of Nepal.

Table 3-12: Annual iron and steel production.

Year	Iron and steel production (tonnes)
1987-1988	25625
1988-1989	34834
1989-1990	36339
1990-1991	45631
1991-1992	59661
1992-1993	60316
1993-1994	71023
1994-1995	95118
1995-1996	91583
1996-1997	107346
1997-1998	91291
1998-1999	106646
1999-2000	131354
2000-2001	135951
2001-2002	140000
2002-2003	163940
2003-2004	169310
2004-2005	166451
2005-2006	
2006-2007	
2007-2008	
2008-2009	
2009-2010	
2010-2011	35340
2011-2012	40641
2012-2013	35340

Data sources: Economic Survey (MoF, 2011) and other annual reports.

iv) Filling Data Gaps

For activity data, several sources were investigated to fill the gaps in production and import. The gap in clinker production data was partially filled by that of Udayapur Cement Industry. The import of refrigerants used as substitutes of ODS is also partially obtained from MoPE (2017). The rate of change in cement demand was obtained from Nepal Cement Manufacturers' Association (2016).

Tier 1 approach was used for estimating emissions from the consumption of HFCs, PFCs and SF_6, due to the insufficiency of data. This estimation is still helpful to monitor the use of ODS substitutes. Similarly, the use of nitrous oxide (N_2O) could not be quantified from Department of Customs (DoC)data; so, the data of N_2O export from India to Nepal was used.

v) Data Quality Control and Quality Assurance (QC/QA)

The emission data in IPPU sector was verified with existing national inventory and activity data, and checked with trends in Nepal and other Asian countries. The quality of the emission data

was verified by comparing with regional and global datasets such as the Emission Database for Global Atmospheric Research (EDGAR, 2010). The uncertainty in EF and activity data was assessed using the IPCC (2006) guidelines. For the cement production category, the uncertainties inherent in the fraction of clinker in cement under Tier 1 method were assessed. Similarly, it is assumed that imports of all products, such as N_2O and lubricants, are consumed in the same year.

3.5.4. GHG Emissions from IPPU in 2011

Table 3-13 shows GHG emissions from Nepal's IPPU sector in the base year 2011. Though HFC data are not available for 2011, the HFC database of MoPE (2017) from 2013 onwards will be vital. Moreover, the HFC dataset is only the potential emission that may be actually emitted only after several years.

The GHG emissions and precursor emissions are reasonably within the expected values. As in previous National Communications, cement production is the dominant GHG emitter in Nepal's IPPU sector comprising 92% of total emissions from the sector.

Table 3-13: Greenhouse gas emissions from the IPPU sector in 2011

Category	CO_2 (Gg)	N_2O (Gg)	HFC (kg)				CO_2-equivalent (Gg)	NO_x (Gg)	NMVOC (Gg)	CO (Gg)	SO_2 (Gg)
			R134a	R404a	R407a	R410a					
Cement production	350.2						350.2				0.21
Iron and steel production								0.0014	0.0011	0.0000	0.0016
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				
Paper production									0.1457		
Food and beverage production									5.8319		
Total	355.4	0.0035	7475.2	218.0	565.0	5085.0	368.4	0.0	6.0	0.0	0.2

Notes:

a) HFC data is not the actual emission but only the potential emission.

b) Since the HFC data is not available for 2011, the year 2013 has been taken as the base year for this category.

c) GWP values for 100-year time horizon are taken from IPCC Fourth Assessment Report. GWP values of N_2O, R-134a (HFC-134a), R-404A, R-407A and R-410A are taken as 298, 1430, 3922, 2107, and 2088.

3.5.5. Trend in Greenhouse Gas Emission

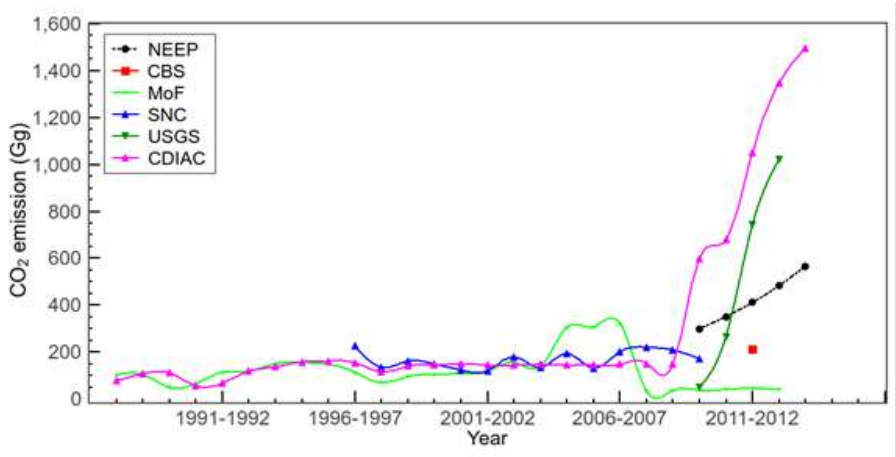
The CO_2 and SO_2 emissions from cement production are estimated for different data sources in Table 3-14 and Figure 3-10. Except MoF, other sources use IPCC (2006) method by deducting the clinker import from the total cement production in Nepal. The MoF data underestimates cement production; this leads to underestimation of GHG emission when the imported clinker is deducted from the production of cement. Data from other sources show high rate of increase in CO_2 emissions from 2010. Data from Carbon dioxide Information Analysis Center (CDIAC, 2016) also exhibits this trend, but at a higher rate than others. This may be due to the use of the cement production data without incorporating the import of clinkers. The NEEP (2012) used only limestone-based industries in the calculation. Thus, the rate of increase in CO_2 emissions in NEEP data is lower than that in CDIAC data. Accordingly, emissions from NEEP data can be used with greater confidence.

Table 3-14: Annual emissions of air pollutants from the cement industries in Nepal.

Year	CO_2 emission (Gg)				SO_2 emission (Gg)
	IPCC (2006) method			IPCC (1996) method	IPCC (2006) method
	NEEP	CBS	USGS	MoF	NEEP
1987–1988				101.8	
1988–1989				103.1	
1989–1990				47.9	
1990–1991				64.4	
1991–1992				112.4	
1992–1993				117.4	
1993–1994				149.4	
1994–1995				154.8	
1995–1996				146.6	
1996–1997				113.0	
1997–1998				69.3	
1998–1999				95.0	
1999–2000				102.6	
2000–2001				107.2	
2001–2002				116.2	
2002–2003				154.8	
2003–2004				139.3	
2004–2005				304.1	
2005–2006				305.9	
2006–2007				321.2	
2007–2008				35.5	
2008–2009				35.4	
2009–2010	298.6		48.0	35.9	0.18
2010–2011	350.2		265.0	39.8	0.21
2011–2012	**410.8**	212.8	742.9	43.8	
2012–2013	**481.8**		1021.1	41.0	
2013–2014	**565.2**				

***Note*:** The emission values from NEEP for 2011-2012 to 2013-2014 are projections. Sources are: NEEP: Nepal Energy Efficiency Programme (NEEP, 2012); CBS: Central Bureau of Statistics (CBS, 2014b); MoF: (MoF, 2011) and other annual reports; USGS: U.S. Geological Survey (USGS, 2016).

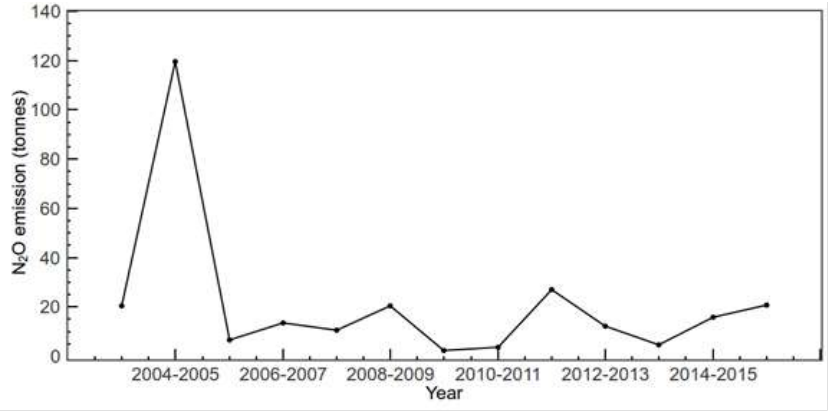
Figure 3-10: Trend of annual CO_2 emission in Nepal using different datasets



Notes: NEEP: Nepal Energy Efficiency Programme (NEEP, 2012) The NEEP data from 2011-2012 to 2013-2014 are projections. Sources are: CBS: Central Bureau of Statistics (CBS, 2014b); MoF: (MoF, 2011) and other annual reports; SNC: Second National Communications (MoSTE, 2014); USGS: U.S. Geological Survey (USGS, 2016); CDIAC: Carbon dioxide Information Analysis Center (CDIAC, 2016).

The trend of the emission of precursor (indirect) gases such as NO_x, CO, SO_2 and NMVOC, potential HFC emissions and N_2O emissions are estimated and presented in Table 3-13; Table 3-14 and Figure 3-11. These tables and figures do not indicate a clear trend of emissions of these indirect gases, as opposed to the one for CO_2 emissions.

Figure 3-11: Trend of annual N_2O emission in Nepal



However, the contribution of non-energy uses of paraffins and lubricants to emission of CO_2 show a relatively constant trend (Table 3-15).

Table 3-15: Annual CO_2 emission from lubricants and paraffin wax uses.

Year	CO_2 emission (Gg)	
	Lubricant use	Paraffin wax use
2007-2008	1.9	2.0
2008-2009	1.9	3.1
2009-2010	1.1	2.0
2010-2011	2.9	2.3

Year	CO_2 emission (Gg)	
	Lubricant use	Paraffin wax use
2011-2012	3.0	2.1
2012-2013	3.5	2.8
2013-2014	3.7	2.1
2014-2015	3.9	2.2
2015-2016	4.4	2.3

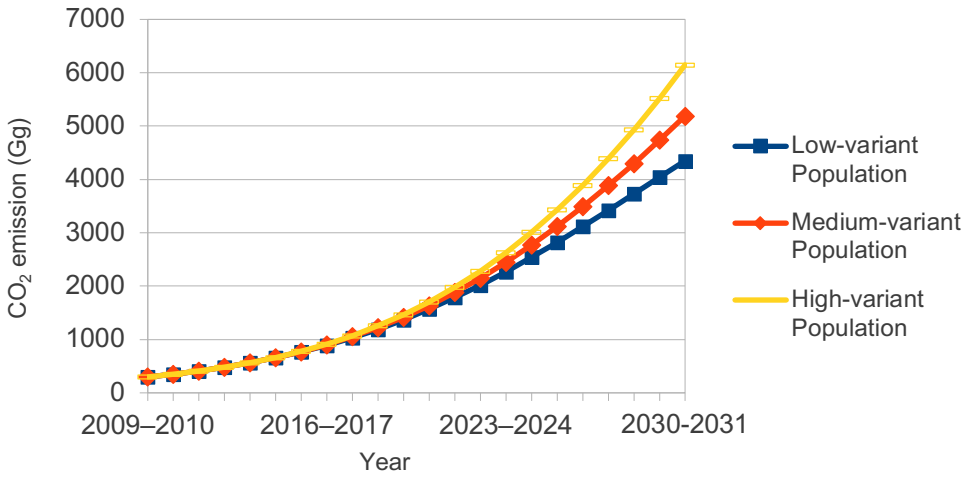
3.5.6. GHG Emission Projection

Using the past trend of emissions from cement production, CO_2 emission is projected up to 2030 (Table 3-16; Figure 3-12). Since the trend of overall IPPU sector is difficult to ascertain and cement is the most dominant category in IPPU, the projection is only estimated for the emissions from cement production. The growth in population, number of households or construction projects affects the demand for cement. For projecting GHG emissions, annual growth of cement production is assumed to be 17.3%, based on estimate by NEEP (2012). This rate is also consistent with the estimate of Nepal Cement Manufacturers' Association. Then emission is projected according to the low-variant, medium-variant and high-variant population projection scenarios given by CBS (2014). The projection shows that cement production may contribute 4000 to 6000 Gg of CO_2 per annum by 2030.

Table 3-16: Projected CO_2 emission from cement industries.

Year	Projected CO_2 emission (Gg)	Year	Projected CO_2 emission (Gg)
2012	410.8	2021	1726.0
2013	481.8	2022	2024.4
2014	565.2	2023	2374.5
2015	662.9	2024	2785.1
2016	777.5	2025	3266.6
2017	912.0	2026	3831.5
2018	1069.6	2027	4494.0
2019	1254.6	2028	5271.1
2020	1471.5	2029	6182.5
		2030	7251.6

Figure 3-12: Projected trend of annual CO2 emission from cement industries.



3.6. Agriculture, Forestry, and Other Land Use

3.6.1. Brief Summary

This section presents GHG emissions and removal from Nepal's agriculture, forestry, and other land use (AFOLU) activities for the base year 2011. Emission is computed with IPCC methodologies for both direct GHGs (CO_2, CH_4, N_2O) and indirect GHGs (CO and NO_x). In 2011, a total of 37,984 Gg CO_2-eq was emitted from this sector. The livestock (3A) sub-category contributed an emission of 17,664.07 Gg CO_2-eq yr^{-1}, an increase of 43.5% from 2001; aggregated sources and non-CO_2 emission sources on land (3C) contributed 11,499.68 Gg CO_2-eq yr^{-1}, while the land (3B) subcategory acted as the net sink 17,077.81 Gg CO_2-eq yr^{-1} due to removal of CO_2 in forestland and non-forest lands (including shrublands). If the trend continues under business-as-usual scenario, except sink from the forest cover increase, other activities will increase emissions of up to 25% by 2030. Uncertainties are high in both emissions and removals from the AFOLU sector due to the lack of national emission factors and consistent activities data.

3.6.2. Overview of the Sector

Agriculture and forestry play a tremendous role in Nepal's economy by employing 65% of the population and contributing 36% towards the Gross Domestic Product (GDP) (CBS, 2016). Data shows that 29% of the land is used for agriculture, while 12% is utilized as grass land and pasture areas (MOAD, 2011). The forests and other woodlands cover 44.74% area of the country (DFRS, 2015).

The AFOLU sector comprises emissions from livestock, land conversion, and aggregate sources and non-CO_2 emissions sources on land. This sector also comprises carbon sink due to the conversion of other land use categories into forests. If forests are managed in a sustainable way, extraction and production of biomass in the forests does not have an impact on GHG inventory.

3.6.3. Data and Methods

Data Sources. The GHG emissions and removals are calculated for activities in three sub-categories (Livestock, Land, and Aggregated Source and Non-CO_2 Emission Sources from Land) (Table 3-17).

Table 3-17: Overview of AFOLU categories, subcategories, and emission computation.

Activities	CO_2	CO	Methane (CH_4)	Nitrous oxide (N_2O)
Livestock (3A)				
Enteric fermentation (3A1)			√	
Manure management (3A2)			√	√
Land (3B)				
Forest Land	√			
Non-Forest Land	√			
Aggregate sources and non-CO_2 emissions sources on land (3C)				
Biomass burning (3C1)	√	√	√	√
Liming (3C2)	√			
Urea application (3C3)	√			
Direct N_2O emissions from managed soils (3C4)				√

Activities	CO_2	CO	Methane (CH_4)	Nitrous oxide (N_2O)
Indirect N_2O emissions from managed soils (3C5)				√
Indirect N_2O emissions from manure management (3C6)				√
Rice cultivations (3C7)			√	

Methodology. GHG emissions and removals by sources in the AFOLU sector are computed from activity data using the 2006 IPCC Guideline. The main sources used for this inventory are shown in Table 3-18.

Table 3-18: List of AFOLU activity data and the data sources

Category	Sub-Category	Data Need	Data Source
3A Livestock	3A1 Enteric Fermentation	Number of Animals (cattle, buffalo, goat, sheep, swine, mule and assess, horse)	Ministry of Agricultural Development (MoAD), CBS
	3A2 Manure Management	Number of Animals (cattle, buffalo, goat, sheep, swine, mule and assess, horse, poultry, rabbit, duck)	MoAD, CBS
3B Land	3B1 Forest land	Land use maps, Land use change map, Land use change matrix	MoFSC
		Biomass estimate for 5 IPCC pools (Above ground biomass, below ground biomass, deadwood, herb, litter and soil)	MoFSC, DFRS, IPCC
		Climate zones, soil classification and ecological zone maps	IPCC database, DHM, DFRS
		Industrial round wood	MoFSC, DFRS
		Wood fuel production	MoFSC, DFRS
		Areas affected by fire	FAOSTAT
	Non-Forest land	Land use maps, Land use change map, Land use change matrix	MoFSC, ICIMOD
		Biomass estimate for 5 IPCC pools (Above ground biomass, below ground biomass, deadwood, herb, litter and soil)	MoFSC, DFRS, IPCC
		Climate zones, soil classification and ecological zone maps	IPCC database, DHM, DFRS
3.C Aggregated Source and non-CO2 emissions on land	3C1 Biomass burning	Areas affected by fire in cropland, forestland, and grassland	MoFSC, DoF, FAOSTAT
	3C2 Liming	Quantity of agriculture limes used	DoA-SMD, Agriculture Inputs Company Ltd

Category	Sub-Category	Data Need	Data Source
	3C3 Urea application	Annual Urea consumption figures	MoAD, CBS, FAOSTAT
	3C4 Direct N_2O emissions from manage soils	Annual generic NPK consumption	MoAD, CBS
	3C5 Indirect N_2O emissions from manage soils	Annual crop production in tonnes per annum	MoAD, CBS
	3C6 Indirect N_2O emissions from manure management	Number of Animals (cattle, buffalo, goat, sheep, swine, mule and assess, horse, poultry, rabbit, duck)	MoAD, CBS
	3C7 Rice cultivation	Annual rice production areas	MoAD, CBS
		Proportions of annual rice production area under rain fed, irrigated and upland systems	MoAD, CBS

i) Choice of Emission Factors

Due to the lack of national emission factor, default IPCC emission factors were used in GHG emission, using Tier 1 approach. For example, total CH_4 emission from enteric fermentation was computed by multiplying the number of animal heads (an activity data) with CH_4 emission factor (EF).

ii) Key Categories

Key categories applicable for national situation were used according to the IPCC methodology. Each of the outlined categories of the inventory methodology was revisited.

Livestock (3A)

Livestock comprises a quarter of total agricultural Gross Domestic Product (GDP). The contribution of livestock to the national economy has increasing the recent decades and the number of livestock – almost all kinds – is increasing. Livestock contributes to GHG emission in two principal ways: Enteric fermentation and manure management. Enteric fermentation takes place in rumen when CH_4 is produced as a result of microbial fermentation of the feed consumed by the animals. Cattle, buffalo, goat, and sheep are the primary CH_4 producers, whereas a number of other livestock also contribute to CH_4production at different scales. Manure management produces CH_4 when anaerobic respiration takes place in the heap of manure.

Land (3B)

According to the IPCC Guidelines (2006), land category (3B) has been divided into six sub-categories: Forest Land (3B1), Crop Land (3B2), Grassland (3B3), Wetland (3B4), Settlement (3B5) and Other Lands (3B6), however, due to the lack of the land cover and land cover change data of reference year, this report only considers the land categories as Forest Land and Non-Forest Land and assess the landcover change among those two categories.

- **Forest Land (3B1).** It covers estimate of emission and removal from Forest Land, Remaining Forest Land and Land Converted to Forest Land. Land cover data from Forest Emission Reference Level report of MoFSC (2017), DFRS (2015), topographic map of 1992,

and data from Land Resources Mapping Project (LRMP) were used for this category and other land categories.

- **Non-Forest Land (including shrublands)**. Non-Forest land consists of the every landcover other than the Forest Land. As reliable data were not available for the reporting period on various land cover and land cover change classes, all land cover other than forests were aggregated in this land class.

Aggregate Source and Non-CO_2 Emission Sources on Land (3C)

Agriculture is a principal economic sector, which employs 65% of Nepal's population. Agriculture land covers 4,243,160 ha (29.7%), with per capita land availability of 0.082 ha. More than 53% of households operate in a farm size of less than 0.5 ha (CBS 2011). Various agricultural activities emit GHGs, mainly Methane and Nitrous oxide. These activities are described below.

Agriculture Liming. Adding carbonates in the forms of limes (e.g., calcic limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$) reduces soil acidity and improves plant growth, which emits CO_2. Nepal's farmers sometimes use the agriculture lime to neutralize the soils. The south-eastern Terai lands are relatively more acidic compared to other parts of the country.

Urea Application. Urea is the most common nitrogenous fertilizer used for crops and vegetables in mostly road-accessible areas such as the Terai and Kathmandu. The total amount of urea applied (tones per year) was multiplied by EF.

Direct and Indirect N_2O emissions from Managed Soils. Direct N_2O emissions were calculated by multiplying the amount of annual synthetic Nitrogen (N) applications in the form of nitrogenous fertilizers (excluding urea as that was calculated separately) in kg N per year with the respective EF. Indirect N_2O emission was the result of the amount of annual synthetic N applications that volatilizes as NH_3 and NO_X and is lost through runoff and leaching in kg N per year.

Indirect N_2O Emissions from Manure Management. Nitrogen from animal wastes, biological N-fixation, and cultivation of mineral and organic soils are important sources of Nitrous Oxide (N_2O) emissions from the soil (IPCC 1997). N- inputs to agricultural soils also contribute to indirect N_2O emissions through leaching, run off and volatilization (IPCC, 2006). Data was obtained from manure production calculated from the number of animals, and a standard was used to calculate the production of N gases from a kg of manure. As the country level data was not available, a global figure was used to interpolate data. The farmyard manure (FYM) and compost data were calculated from the number of livestock through a study on the amount of FYM and compost produced by an animal.

Rice Cultivation. Methane emission from paddy field was calculated using harvest area of rice in different paddy field type and water regime as well as organic matter application, which was multiplied by the number of cultivation days in a year and emission factor and scale factors. Two paddy land types are found in Nepal: Uplands and Lowlands.

Uplands never hold enough water for long period to produce methane. Lowlands, which include rainfed, irrigated, water logged and wetland, produce methane. But Nepal's data is only available for two categories - rainfed and irrigated. For irrigated or lowland areas additional sub-categories are mentioned but their data is not available. Only about two-thirds of agriculture land is irrigated in the country (CBS, 2011; APBS, 2014).

Biomass Burning. Biomass burnings in Nepal occurs in forests, grasslands, and agriculture fields. Burning of agricultural crops/commodities residues in the field is a common practice in certain parts of Nepal. National emission factors from burning agricultural residues for both carbon and nitrogen are also not available. Both uncontrolled (wild fires) and managed (prescribed) fire can have a major impact on non-CO_2GHG emission from several lands, like forests and grass lands. Non-CO_2 emission (CH_4, N_2O) from the cropland remaining cropland, Forest land remaining forest land, Grassland remaining grassland and Other land remaining other land are generally associated with burning of residues of that land.

The percent of the biomass burned on the land should be estimated for considering a fraction removed before burning due to animal consumption, decay in the field, and used in other sector (e.g., bio-fuel, building material, animal feeding). In this inventory, biomass burning in the forests, grasslands, and agriculture fields are considered just for the information as emission from biomass burning is neutralized by the growth of vegetation in subsequent year.

iii) Activity datasets

Animal population (3A1 and 3A2). Animal population data is required for computation of GHG from the enteric fermentation and manure management. Two sets of data were available. The data from the MoAD (2011 to 2015) were considered for all available animal population. If the data were not available from MoAD, the CBS data were used. For manure management, masses of animals were used from IPCC default database on masses for Asia/Indian sub-continent. The annual N-excretion rate per head was computed using the formula provided in the 2006 IPCC guideline.

Land use change (3B). The refined land use datasets (MoFSC, 2017) were used to calculate the annual carbon stock change (Table 3-19). Only forest and non-forest land use classes were used for the emission calculation. Corresponding default emission factors and other data were used from the guideline considering climatic zone, physiographic range, forest types.

Table 3-19: Land classes change from 2000 to 2010 in Nepal (in ha)

Land class	Forest land	Non-forest land	Total (2000)
Forest land	5918250	26970.6	**5945220.6**
Non-forest land	19394.4	8753484.9	**8772879.3**
Total (2010)	**5937644.4**	**8780455.5**	**14718099.9**

Source: MoFSC, 2017.

Biomass burning (3C1). The reliable estimate of biomass burning areas and the amount of biomass burned do not exist in national records. Thus, the biomass burning data were obtained from the FAOSTAT (2016).

Liming (3C2). Limes applied in Nepal's agriculture are not recorded for long period of time. Data of the Agriculture Inputs Company Ltd and the Soil Management Directorate, Department of Agriculture suggests about 600-700 tonnes of agriculture lime being used in Nepal in 2016. An estimated total target purchase and the sale of lime for agriculture was 1,000 metric tons in 2016/17, however all the target amount was not achieved. Even though some factories are using Dolomite, the quantity of use is relatively in small percent (~5%). The annual amount of 500 tonnes, according to use estimation in 2011-2012, are used to calculate the total amount of CO_2 emission through liming process.

N-Fertilizer and urea application (3C3 and 3C4). Urea has 46% of N-content. The amount of urea application in agricultural land is rapidly increasing in Nepal. For instance, it was 63,020 tonnes

in 2003 and reached 100,825 tonnes in 2011 (Table 3-20). The application of N-fertilizer was also calculated from the amount of nitrogenous fertilizers other than urea.

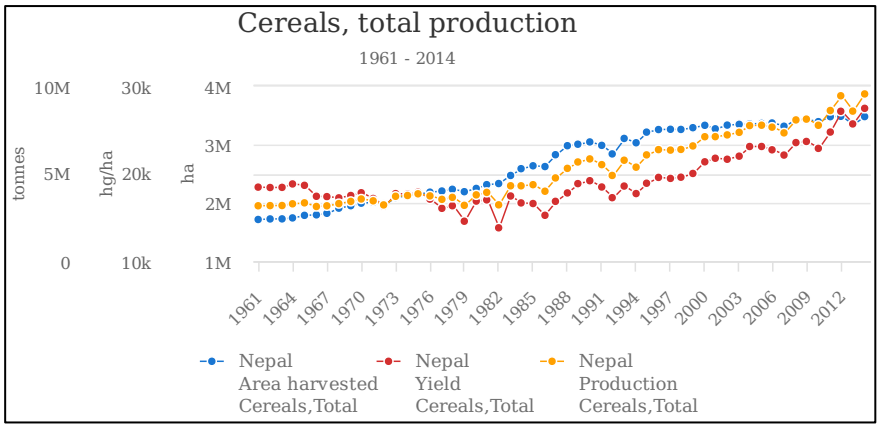
Table 3-20: Quantity of nitrogen-based fertilizer and Urea use, 2002-2011

Fertilizer type	Tonnes, Year									
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Urea	0	63020	107995	22531	42262	7147	9600	50489	85191	100825
N-Fertilizer	21838	5465	8118	2856	8781	1939	2790	28331	43148	54769

Source: MoAD, 2015.

Crop production (3C4). Crop production data includes, annual cereals crop production, improved and local (seed) crops, and vegetables. Cereal crop production has increased between 1991-2011, but without significant increase in cropped area (Figure 3-13).

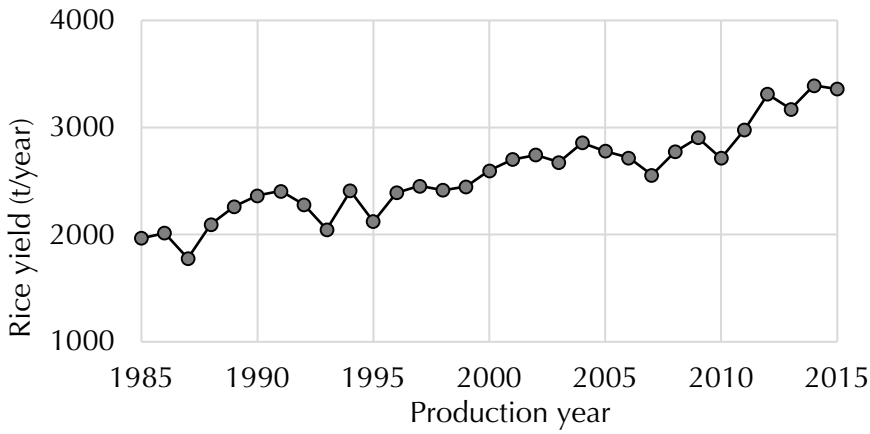
Figure 3-13: Crop production ('000 ton/year), 1991-2011, Nepal



Source: FAOSTAT, 2016.

Rice Cultivation (3C7). Rice is a major staple crop in Nepal and is grown in areas up to 3,000 above the mean sea level (Sapkota et al., 2010; Paudel, 2011). Nearly 50% of cultivable land, in both lowland and upland, is suitable for rice. The cultivation period differs for physiographic regions, such as Terai 90 days, mountain 120 days, and Himalayan range 150 days (for irrigated category) and Terai 120 days, mountain 150 days, and Himalaya 180 days for non-irrigated (rainfed). The data on rice category was obtained from MoAD (Figure 3-14; Table 3-21)

Figure 3-14: Rice yield (tonne/year), 1991-2011



Source: MoAD, 2015.

Table 3-21: Rice production areas by types, FY 2014/2015

Type	Area (ha)
Irrigated	919167
Non-irrigated	506179

Source: MoAD, 2015.

iv) Filling Data Gaps

High quality, consistent, segregated and time series data are lacking in the AFOLU sector. Land cover and land cover change data across all the classes identified by IPCC were not available for the communication period. Similarly, available data were aggregated ones and several of them were not available for a longer period. For example, data for rice is only available for irrigated and rainfed lands, and not disaggregated for upland and lowland.

The observed data gap includes the unavailability of decadal/annual change in the land use, inconsistency in the land category data maintained by the Government (FRA, DFRS, MoFSC) and other national and international organization (ICIMOD and FAOSTAT). The land use data of 2000 and 2010 was used and the average annual rate of change was calculated. For addressing data inconsistency, the most updated data source (forest reference level, by MoFSC) was used.

v) Data Quality Control and Quality Assurance

This inventory carefully considered ensuring the data quality control and quality assurance (QA/QC). A QA/QC plan was developed which considered the quality of the data. The inventory suffers both from non-availability of activity data and national EF, as required by the 2006 IPCC Guideline. Nepal has a traditional agriculture for which no suitable emission factor has been developed. Further, the activity data are not disaggregated as required for comparing with IPCC Emission Factor Database. For example, paddy area data is not disaggregated for upland paddy and lowland paddy. The upland paddy is rain-fed. Even among the low land paddy, some areas have no irrigation and crop is grown based on floodwater/rain water. In some other areas, irrigation is very limited and, most of the time, the field remains aerated. In some other cases, irrigation is available once a week or so in rotation from farmer to farmer or even plot to plot. There are still some paddy areas with continuous flooding. Such data limitation puts challenges on estimating the GHG emission in Nepal precisely.

3.6.4. GHG Emissions and Removals from AFOLU

The overall GHG emissions and removal from the AFOLU sector is presented in Table 3-22.

The emission from manure management is smaller than enteric fermentation. The emission from manure management per capita is lower than the IPCC standard, because manure is not stored and used as liquid and often heaps are exposed to the sun, reducing anaerobic action.

The GHG emission and removal from the forest land is in line with the National Forest Reference Level Report (2000-2010) (MoFSC, 2017). However, FREL report estimations did not consider GHG removals in forest through natural biomass growth and long-term sustainable improvements in management as a result of community-based forest management and natural biomass growth.

While there is some emission from the Forest land due to deforestation and degradation, forest land is a net sink of CO_2. Conservation, participatory and sustainable management of forest resources played a part in enhancing the carbon sink in Nepal's forests.

Table 3-22:GHG emissions and removal (Gg) from AFOLU sector, 2011

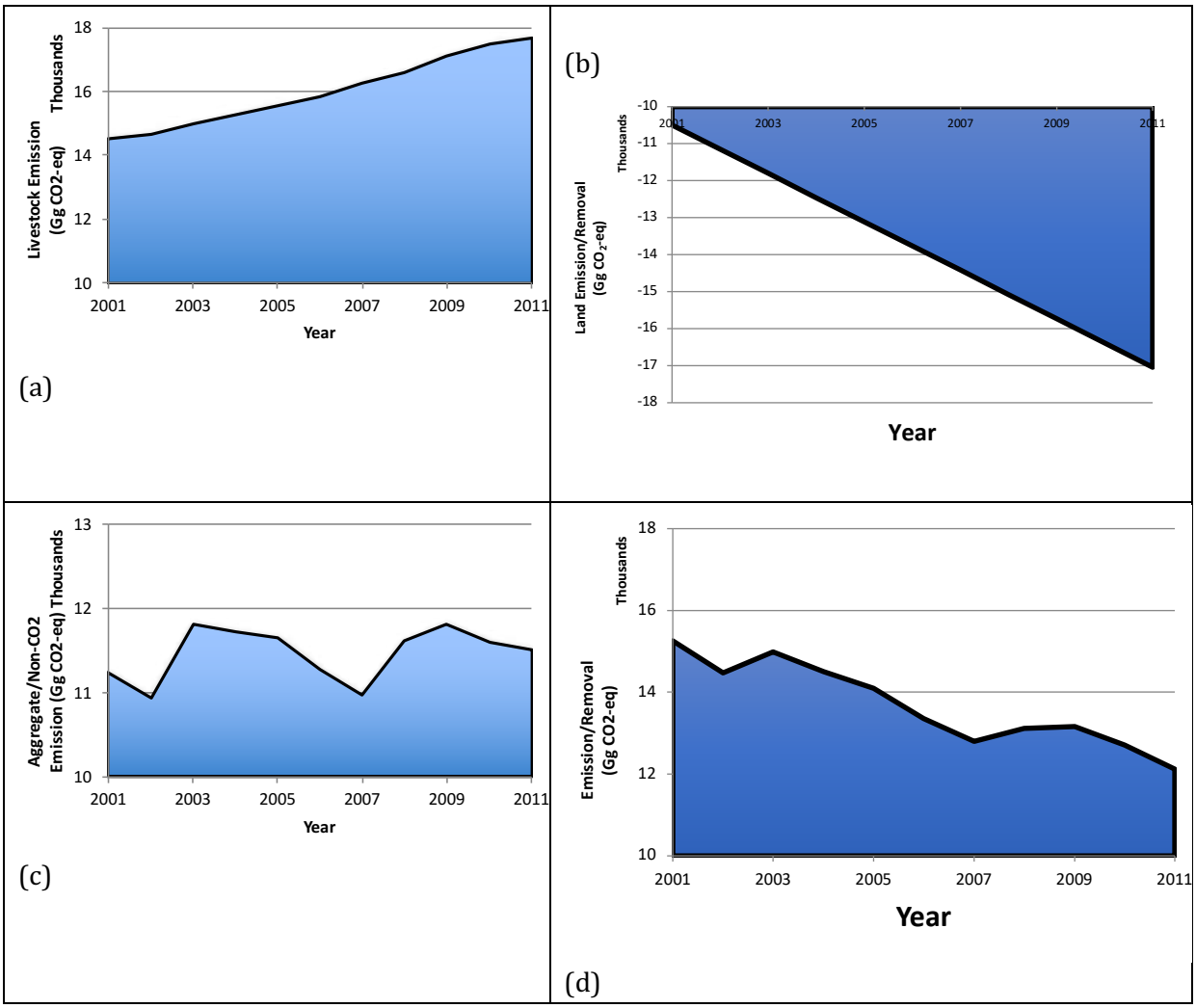
Activities	GHG Emission (Gg), 2011						Remarks
	CO_2	CH_4	N_2O	CO_2-Eq	CO	NO_x	
TOTAL AFOLU	**-16231.43**	**882.36**	**21.12**	**12121.33**			
Livestock (3A)		**705.49**	**0.09**	**17664.07**			
Enteric fermentation (3A1)		648.74		16218.50			
Manure management (3A2)		56.75	0.09	1446.63			
Land(3B)	**-17042.42**			**-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**	**186.44**	**2.87**	
-Forest	*229.85*	*12.19*	*0.47*	*673.51*	*186.44*	*2.87*	
-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 N2O emissions from managed soils (3C4)			0.86	255.12			
Indirect N2O emissions from managed soils (3C5)			*0.23*	*67.93*			
Indirect N2O emissions from manure management (3C6)			*19.33*	*5760.30*			
Rice cultivations (3C7)		159.00		3974.91			
Biomass burning (3C1)	***229.85***	***17.88***	***0.62***	***860.25***			***Not included in inventory***

The emission from biomass burning is not added to the national GHG inventory as it is assumed that the emission will be overcome by the regeneration on the land in the subsequent year. Similarly, indirect emission of gases was also not considered for the inventory of GHG.

3.6.5. Trend and Projection in Greenhouse Gas Emission

Figure 3-15showsthe trends of GHG emissions and removals from the AFOLU sector during 2001 to 2011. Emissions increased from the livestock and aggregate sources and non-CO_2 emissions sources on land categories, while removals from land category increased steadily. Emissions from livestock category increased by 43.5% from 12,308 Gg CO_2-eq yr^{-1} in 2001 to 17,665 Gg CO_2-eq yr^{-1} in 2011. The GHGs sink was only recorded from the forest and cropland classes, whereas other classes: settlement, wetland, grassland, and other land contributed to the GHG emissions.

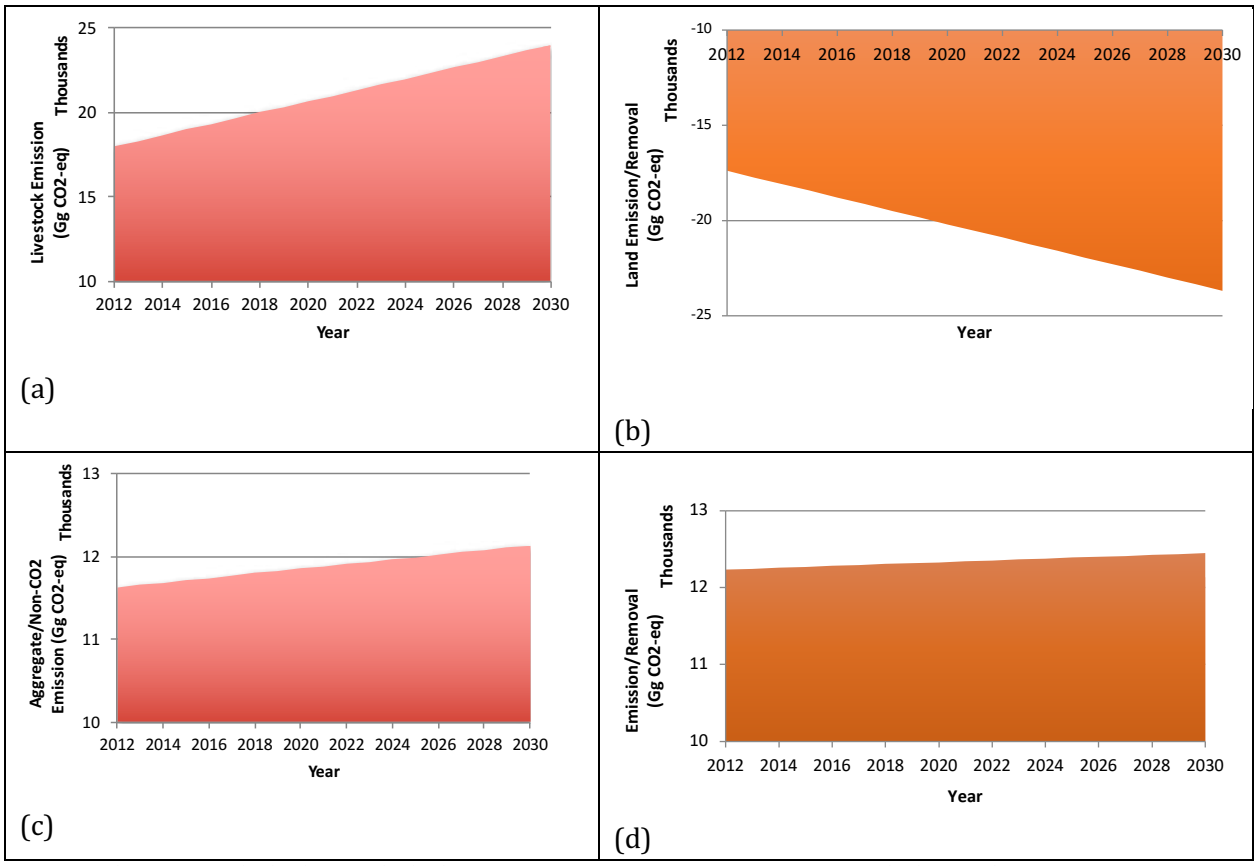
Figure 3-15: GHG Emission Trend from AFOLU, 2001-2011



Notes: a) Livestock (3A), b) Land (3B), c) Aggregate and non-CO_2 emission sources (3C), and d) overall AFOLU sector.

The contribution of agriculture to GHG emission has gradually increased. Total emission increased from 18,240 Gg in 2001 to 26,621 Gg in 2011, an increase of 46.0%. Similarly, projections of GHG emission from AFOLU sector for 2012-2030 are shown in Figure 3-16.

Figure 3-16: Projection of GHG Emission from AFOLU and categories until 2030.



Notes: a) Livestock (3A), b) Land (3B), c) Aggregate and non-CO_2 emission sources (3C), and d) overall AFOLU sector.

3.7. Waste Sector

3.7.1. Brief Summary

This section presents GHG emissions from waste sector, namely solid waste management, biological treatment of waste, incineration and open burning of solid waste and waste water treatment and discharge. Solid waste is mostly ignored in rural Nepal and is managed locally, such as in backyards or open fields, with negligible GHG emission. But solid waste handling in urban areas, wastewater treatment and its handling generate significant quantities of GHG. Typically, methane (CH_4) emissions from solid waste disposal sites and wastewater discharge contribute the most to the emissions from waste sector.

This inventory used 2006 IPCC guidelines, using Tier 1 method due to the unavailability of data for higher tier methods. GHG emissions are calculated by using emission factors and activity data for the base year 2011.

3.7.2. Overview of the Sector

Disposal and treatment of solid waste and wastewater produces several GHGs, most significantly methane gas (CH_4). It is released during the breakdown of organic matter in landfills. Other forms of waste disposal also produce GHGs but mainly in the form of biogenic carbon dioxide (CO_2) and non-methane volatile organic compounds (NMVOCs) as well as smaller amounts of nitrous oxide (N_2O), nitrogen oxides (NO_x) and carbon monoxide (CO) (GRIDA/UNEP, 2016).

Waste management practices (e.g., landfill gas recovery, improved landfill practices, and engineered wastewater management) can mitigate GHG emissions. Reduced waste generation and the exploitation of energy from waste (landfill gas, incineration, and anaerobic digester biogas) contribute to an indirect reduction of GHG emissions through the conservation of raw materials, improved energy and resource efficiency, and fossil fuel avoidance (Bogner, 2008).

In most rural Nepal, waste is disposed in haphazard manner with no anaerobic processing. So, emission is mostly CO_2. However, in urban areas, most of the waste is disposed in landfills, open dump, river banks and, in some towns, by land filling in low lying areas. These disposals lead to emission of large quantities of CH_4.

Similarly, household and industrial wastewater is also a significant contributor to GHG emission. The method of handling of wastewater is an important factor to CH_4 emission (IPCC, 2006). In Nepal, most of domestic, commercial and industrial wastewater is usually discharged into the open pits/latrines, aerobic shallow ponds, and streams and rivers with few exceptions of discharging in septic tanks and deep lagoons. This process of wastewater handling can be important in terms of GHGs emission in Nepal.

Classification of Solid Waste

The following four categories are considered in the waste sector: Solid Waste Disposal (4A), Biological Treatment of Solid Waste (4B), Incineration (4C) and Open Burning and Wastewater Treatment and Discharge (4D).

a. *Solid Waste Disposal*: Municipal Solid Waste disposal consists of household and business waste. The emissions can be estimated considering the population, per capita waste generation, and quantity generated and deposited in disposal sites. As separate disposal of solid waste and industrial waste is not practiced in Nepal, it is assumed that total solid waste disposal is the combination of both.

b. *Biological Treatment of Solid Waste*: Composting and biogas production from solid waste are two widely used biological treatment technologies to manage solid waste. Composting is the natural biological breakdown of organic material into a more stable organic substance. During aerobic composting, microorganisms consume organic matter (carbon) and release CO_2, converting a large fraction of degradable organic carbon (DOC) into CO_2. CH_4 and N_2O are also formed through composting.

Biogas refers to a mixture of different gases produced from the anaerobic breakdown of organic matter. Biogas produced with solid waste consists of around 55-60% methane and remainder consisting of CO_2 and other gases (Edelmann, 2011). N_2O is also produced but is assumed to be negligible.

c. *Incineration and Open Burning*: Incineration involves the combustion of organic substances of waste. It converts waste into ash, flue gas, and heat. Flue gas consists of GHGs like N_2O and CO_2, their quantity depending upon the composition of waste. Modern incineration plants recover heat from the plant making it a net energy positive system. Open burning of waste reduces its volume in waste dumps including landfill sites. It is an inadvertent source of persistent organic pollutants, producing harmful GHG gases like CO_2 and NO_x (IPCC, 2006).

d. *Wastewater Treatment and Discharge*: Wastewater handling is the major source of methane and nitrous oxide emission. For domestic wastewater, biological oxygen demand (BOD), type of treatment systems and the amount of protein intake per person per year was used for estimating the emission. Anaerobic decomposition of organic component present in wastewater generates methane gas. Similarly, Nitrous oxide (N_2O) is emitted from human sewage through nitrification and denitrification of nitrogen present in the sewage (IPCC, 2006).

3.7.3. Data and Methods

This inventory adopted 2006 IPCC Guideline to estimate GHG emission from the waste sector. It used Tier 1 methodology due to the lack of sufficient data required for use in higher tier methods. When country specific data were not available, data from reliable international sources were used. When there was complete absence of activity data, expert judgment was used and its assumptions documented.

Solid Waste Disposal (4A)

The methane emission from solid waste disposal was estimated using first order decay (FOD) method with mainly default activity data and default parameters. As first tier model is time series, disposals from 1991 were considered, and the effect of disposals prior to 1991 were considered negligible. The equation for FOD in the Waste Model (IPCC, 2006) was used:

$$\mathbf{CH_4\ Emission\ T\ (Gg/yr)} = \left[\sum_x CH_4\ generated_{x,T} - R_T\right] * (1\text{-}OX_T)$$

where,

CH_4 Emissions = CH_4 emitted in year T, Gg

T is the inventory year for which emissions are calculated

x is waste category or type/material

R_T = recovered CH_4 in year T, Gg

OX_T = oxidation factor in year T, (fraction)

Data on per capita waste generation, disposal and collection and waste characteristics was adopted from ADB (2013). Biodegradable solid waste consisting of food waste, garden waste and nappies were considered for methane emission. Degradable organic carbon (DOC) of municipal solid waste was estimated with IPCC equation (IPCC 2006). Default values from IPCC Guidelines (IPCC, 2006) were adopted for all other necessary parameters and DOC.

Biological Treatment of Solid Waste (4B)

Biological treatment of solid waste generates emissions of CH_4, CO_2 and N_2O through aerobic or anaerobic digestion. Composting is the most common practice with which farmers produce organic manure through aerobic decomposition. In the process, a large fraction of DOC in waste is converted to CO_2. CH_4 and N_2O can both be formed during composting. In recent decades, organic waste is also increasingly used to generate biogas through anaerobic digestion. The resulting biogas consists of both CO_2 and CH_4 and a negligible amount of N_2O.

The default method for estimation of CH4 emissions is

$$\mathbf{CH_4\ Emissions} = \sum_i (M_i . EF_i) . 10^{-3} - R$$

where,

CH_4 Emissions: total CH_4 emissions in inventory year, Gg CH_4
M_i: mass of organic waste treated by biological treatment type i, Gg
EFi: emission factor for treatment i, g CH_4/kg waste treated
i: composting or anaerobic digestion
R: total amount of CH_4 recovered in inventory year, Gg CH_4.

Default method for estimation of N_2O emissions is

$$\mathbf{N_2O\ Emissions} = \sum_i (M_i . EF_i) . 10^{-3}$$

where,

N_2O Emissions: total N_2O emissions in inventory year, Gg N_2O
M_i: mass of organic waste treated by biological treatment type i, Gg
EF_i: emission factor for treatment i, g N_2O/kg waste treated
i: composting or anaerobic digestion

Open Burning of Waste: CO2 Emissions

Based on the total amount of waste combusted

$$\mathbf{CO_2\ Emissions} = \sum_i (SW_i . dm_i . CF_i . FCF_i . OF_i) . 44/12$$

where,

CO_2 Emissions: CO_2 emissions in inventory year, Gg/yr
SW_i: total amount of solid waste of type i (wet weight) incinerated or open-burned, Gg/yr
dm_i: dry matter content in the waste (wet weight) incinerated or open-burned, (Fraction)
CF_i: fraction of carbon in the dry matter (total carbon content), (fraction)
FCF_i: fraction of fossil carbon in the total carbon, (fraction)
OF_i: oxidation factor, (fraction)
44/12: conversion factor from C to CO_2

i: type of waste incinerated/open-burned such as MSW, industrial solid waste (ISW), sewage sludge, hazardous waste, clinical waste, etc.

CH_4 emissions result from incomplete combustion of waste which is affected by temperature, residence time, and air to waste ratio.

CH_4 Emissions= $\sum_i (IW_i . EF_i) . 10^{-6}$ **Gg**

where,

CH_4 Emissions: CH_4 emissions in inventory year, Gg/yr
IW_i: amount of solid waste of type i incinerated or open-burned, Gg/yr
EF_i: aggregate CH_4 emission factor, kg CH_4/Gg of waste
i: category or type of waste incinerated/open-burned (MSW, ISW, hazardous waste, clinical waste, sewage sludge, etc.)

Burning or incineration of solid waste also results in emission of N_2O. The N_2O emissions are mainly determined by technology, combustion temperature (emitted at relatively low combustion temperatures 500-950 ^oC) and waste composition.

N_2O Emissions= $\sum_i (IW_i . EF_i) . 10^{-6}$ **Gg**

where,

N_2O Emissions: N_2O emissions in inventory year, Gg/yr
IW_i: amount of incinerated/open-burned waste of type i, Gg/yr
EF_i: N_2O emission factor (kg N_2O/Gg of waste) for waste of type i
i: category or type of waste incinerated/open-burned (MSW, ISW, hazardous waste, clinical waste, sewage sludge, etc.)

Wastewater Treatment and Discharge

Wastewater (domestic, commercial and industrial) may be treated on site (uncollected), centralized plant (collected) or disposed untreated. Treatment and disposal of wastewater produce GHGs such as CO_2, CH_4 and N_2O. CH_4 production depends primarily on the amount of degradable organic material in the wastewater, the temperature and the type of treatment. CH_4 generated can be recovered and combusted in a flare or energy device.

The N_2O emissions are associated with the degradation of nitrogen components in the wastewater (e.g., urea, nitrate and protein). The N_2O emissions can occur as direct emissions from treatment plants or from indirect emissions from wastewater after disposal of effluent into water bodies. The emissions from industrial sources are believed to be insignificant compared to emissions from domestic wastewater. Due to lack of sizable functional wastewater treatment facility, it is assumed that all wastewater ends up in river.

Because of inadequate data on industrial wastewater generation and treatment, data on major industrial production were taken from industry statistics and multiplied with wastewater generation per ton of those products, which was further multiplied with BOD/COD data. Anaerobic handling of wastewater was estimated on the basis of collected information and assumptions in line with INC. The values for BOD and COD were adopted from 2006 IPCC Guidelines. Methane emissions from domestic and commercial as well as industrial wastewater were estimated by using following equations (IPCC 2006):

Total CH_4 emissions from domestic (and commercial) wastewater:

CH_4 Emission: $\left[\sum_{i,j}\left(U_i . T_{i,j} . EF_j\right)\right](TOW - S) - R$

where,

CH_4 Emissions: CH_4 emissions in inventory year, kg CH_4/yr
TOW: total organics in wastewater in inventory year, kg BOD/yr
S: organic component removed as sludge in inventory year, kg BOD/yr
U_i: fraction of population in income group i in inventory year
$T_{i,j}$: degree of utilization of treatment/discharge pathway or system, j, for each income group fraction i in inventory year
i: income group: rural, urban high income and urban low income
j: each treatment/discharge pathway or system
EF_j: emission factor, kg CH_4 / kg BOD
R: amount of CH_4 recovered in inventory year, kg CH_4/yr

The CH4 emissions from industrial wastewater treatment:

CH_4 Emissions= $\sum_i[(\boldsymbol{TOW_i - S_i}).\boldsymbol{EF_i - R_i}]$

where,

CH_4 Emissions: CH_4 emissions in inventory year, kg CH_4/yr
TOW_i: total organically degradable material in wastewater from industry i in inventory year, kg COD/yr
i: industrial sector
S_i: organic component removed as sludge in inventory year, kg COD/yr
EF_i: emission factor for industry i, kg CH_4/kg COD for treatment/discharge pathway or systems.
R_i: amount of CH_4 recovered in inventory year, kg CH_4/yr

Nitrous oxide is emitted from human sewage through its nitrification and denitrification. Its emission from human sewage was estimated for whole population of the country for 2011 (with CBS census data). Emission factor and other parameters were adopted from 2006 IPCC Guidelines. Data on per capita protein consumption was taken from FAO (2016). The emission from human sewage was estimated with the following equation (IPCC, 2006).

Indirect N_2O emissions from wastewater effluent discharged into aquatic environments

N_2O Emissions = $\boldsymbol{N_{Effluent} . EF_{Effluent} . 44/28}$

where,

N_2O Emissions: N_2O emissions in inventory year, kg N_2O/yr
$N_{EFFLUENT}$: nitrogen in the effluent discharged to aquatic environments, kg N/yr
$EF_{EFFLUENT}$: emission factor for N_2O emissions from discharged to wastewater, kg N_2O-N/kg N
44/28: conversion of kg N_2O-N into kg N_2O

Activity Datasets

Various national and international data sources were used in this inventory (Table 3-23). There is dearth of comprehensive and reliable data on solid waste sector in Nepal. Census information, water use information and protein intake information were used to prepare GHG inventory due to domestic wastewater handling. Demographic data from previous censuses cannot be directly compared with 2011 census data because the status of many villages has been changed into municipalities but they retain some rural characteristics. Regression analysis was performed to get demographic information for each year and interpolation and

extrapolation carried out to get corresponding solid waste information (when real study data is not available). Similarly, wastewater production was calculated by adding up wastewater produced as a result of industrial production.

Table 3-23: Overview of data used in the inventory

Category	Sub-Category	GHG	Data Required	Data Source
4A. Solid Waste Disposal	4A1. Solid Waste Disposal	CH_4, N_2O	Waste Generation Rate, Amount and Methods of Waste Disposal, Urban Population	ADB, SWMTSC, JICA, CBS
4B Biological Treatment of Solid Waste	4B1. Biological Treatment of Solid Waste	CH_4, N_2O	Fraction of Waste Composed	IPCC Guideline 2006
4C. Incineration and Open Burning	4C2. Open Burning	CH_4, N_2O, CO_2	Amount and type of waste burned	IPCC Guideline 2006
4D. Waste Water Treatment & Discharge	4D1. Domestic Wastewater	CH_4,N_2O	Population Data, Wastewater generated and treated per year, Protein consumption, Type of wastewater treatment system in use.	CBS, FAO, ADB
	4D2. Industrial Wastewater	CH_4, N_2O	Industrial Production Data	CBS, DoI, WB

Urban Population

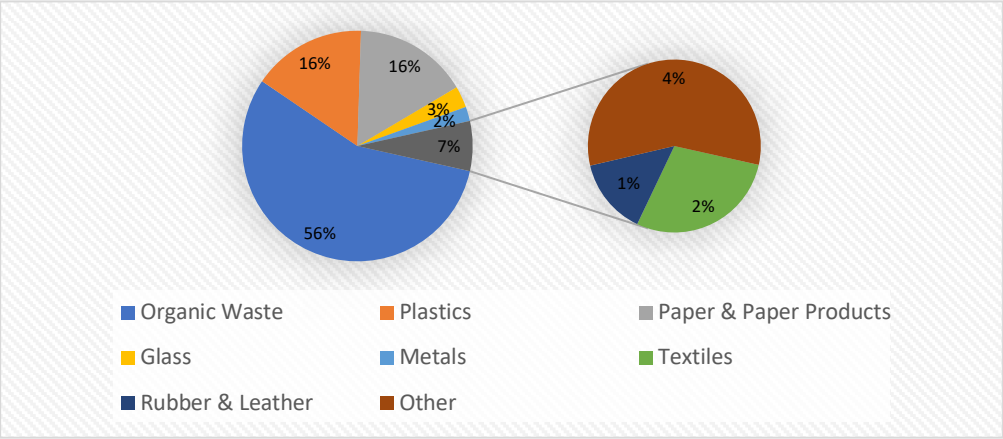
Emission from municipal solid waste disposal consists of domestic, commercial and institutional waste. Information about industrial solid waste is not available, hence assumed to be included in municipal waste. The emissions were calculated using urban population information, per capita waste generation, collection efficiency, and form of disposal activities. Information about population was obtained from national census (CBS, 2012) and solid waste from ADB (ADB, 2013). Urban population of Nepal reached 4.5 Million in 2011, and is projected to reach close to 10 million in 2030 (CBS, 2001; 2014).

Generation and Composition of Municipal Solid Waste (MSW)

Data on per capita solid waste generation was adopted from ADB (2013). In 2011 Nepal's urban population generated over 523,429 tons of solid waste, and its composition of is shown in Figure 3-17. Out of this, only 62% was collected, while the rest ended up in roadsides, riversides and open field. Open burning and composting were only in small scale. Besides household composting, small-scale community and/or municipal composting are also found in some municipalities. With changing lifestyle, per capita waste generation is also expected to increase.

Most of landfills in Nepal are not sanitary one. Those designed as sanitary have outgrown their use and are no more sanitary. Most of the collected MSW is dumped into disposal sites including on riverside or open field disposal. MSW collection efficiency averages 62%, with range between 70% and 90% in major towns, and is <50% in smaller towns. In total, 37% of MSW in Nepal is disposed of in sanitary landfills, although not necessarily in a sanitary manner (ADB, 2013).

Figure 3-17: Composition of Municipal Solid Waste.



Indirect method was used to calculate values for wastewater generation because of inadequate data on wastewater generation and handling. Only 30% of population use water latrine with septic tank and others use either open pit latrine or open sewerage latrine (CBS, 2012). Some major industrial production has been taken from industrial statistics (CBS, 2013) and multiplied with wastewater generation per ton of production of that particular goods, which has been further multiplied with BOD/COD data (IPCC, 2006). Nitrous oxide emission from human sewage was found for whole population of the country for 2011 (CBS, 2011). Data on per capita protein consumption was taken from FAO (2016).

3.7.4. Greenhouse Gas Emission from Waster Sector

The estimate of GHG emission from Nepal's waste sector for 2011 has been presented below. It will first establish the data, parameters and assumptions for individual emissions for (sub-) categories. Subsequently, the overall emissions for the waste sector will be presented.

a) Solid Waste Disposal

Most of waste generated in rural Nepal decomposes aerobically. So, this inventory considered only the emission from urban solid waste (Table 3-24). Per capita generation of solid waste in urban Nepal is 115.705 kg/yr. It represents collection efficiency of only 62%. While 30% of households practice waste segregation and composting, their impact on total waste management is considered minimal. So, 10% of waste is assumed to be open burned and 5% is composted. Waste disposed using open incineration is considered negligible.

Table 3-24: Urban Population and Waste Characteristics 2011.

Urban Population	Waste Generation (ton)	Collection Efficiency	Deposited MSW (tons)	Organic Waste(tons)		Inert Waste (tons)
				Food & Garden	Paper	
4,523,821	523,429	62%	324,511	181,726	51,921	84,373

b) Biological Treatment of Solid Waste

There are many small-scale anaerobic digestion biogas plants in Nepal, but they do not treat solid waste. So, emission from anaerobic digestion of waste is negligible. Composting, though practiced in small scale, generates CH_4, CO_2, and N_2O. It is assumed that 5% of waste in urban areas is used to make compost (Table 2A1, IPCC, 2006). The parameters on biological treatment of solid waste are given in Table 3-25.

Table 3-25: Biological Treatment of Waste in 2011.

Type of Waste	Annual Amount of Waste treated (tons)	Emission Factor		Recovered/Flared CH_4/year
		(g CH_4/kg)	(g N_2O/kg)	
Organic Waste	26,171	**4**	**0.23**	**0**

c) Open Burning

Open Burning of solid waste is widely practiced in Nepal at household to institutional level. But its detailed data is not available; itis assumed that 10% of total solid waste is open-burned. Different parameters for open burning are presented in Table 3-26.

Table 3-26: Open Burning of Waste, 2011.

Waste Open Burned (Gg)	Dry Matter Content (Fraction)	CO_2 Emission			CH_4	N_2O
		Carbon in Dry Matter (Fraction)	Fraction of Fossil Carbon in Total Carbon	Oxidation Factor	Emission Factor (kg/Gg)	Emission Factor (kg/Gg)
52.34	**0.78**	**0.34**	**0.08**	**0.58**	**6500**	**150**

d) Wastewater Treatment and Discharge

There are few waste water treatment systems in Nepal; most are not operating or operating below their capacity. So, indirect method was used to estimate GHG emission. For domestic wastewater handling, organically degradable wastewater (kg/BOD/yr) was computed by multiplying population with IPCC default DOC BOD (kg BOD/Cap/yr). As most wastewater ends up in rivers without any treatment, maximum CH_4 production capacity (kg/CH_4/kg BOD) from organically degradable wastewater of 0.6 and Methane correction factor of 0.1 and Emission Factor (kg CH_4/kg BOD) of 0.06 were used to compute Methane emission. Similarly, per capita protein consumption of 24.09 kg/yr was used to estimate Nitrogen in effluent (FAO, 2016). Similarly, GHG emission from Industrial Wastewater handling was estimated from data of industrial products (Table 3-27).

Table 3-27: Industrial Production (in tons) from 2000/1 to 2013/14

Year	Alcohol Refining	Beer & Malt	Dairy Products	Leather & Tanning	Meat & Poultry	Pulp & Paper	Soft Drinks	Sugar Refining	Veg. Oils
2001	7458	26584	1124000	18300	194000	22516	39567	102131	133504
2002	8587	28795	1158780	18200	199000	25956	43550	91992	135774
2003	8978	29977	1162095	18600	204000	25813	49325	100229	131050
2004	9531	29078	1231853	19000	208000	27992	44376	97758	108281
2005	9495	30439	1274228	19500	215000	28689	45645	101600	115871
2006	10025	31457	1312140	19700	219000	29638	47584	103829	117734
2007	11171	35487	1351394	20100	227000	30959	50336	115609	117398
2008	11495	37040	1388730	20400	234000	31410	53611	121112	100820
2009	12471	56163	1445419	20800	242000	29830	58736	127253	98885
2010	15282	56626	1495897	21200	249000	24280	64215	141774	95588

Year	Alcohol Refining	Beer & Malt	Dairy Products	Leather & Tanning	Meat & Poultry	Pulp & Paper	Soft Drinks	Sugar Refining	Veg. Oils
2011	16660	56756	1556510	21800	277000	28501	74658	160462	85123
2012	13993	65897	1622751	22200	288000	27097	79097	187652	90295
2013	16163	79471	2225945	23400	295000	45043	78354	183880	168895
2014	18083	83402	2572846	23800	N/A	48354	79822	157666	160391

Source: CBS, 2013; DoI, 2004/2005: 2006/2007: 2011/2012; FAO, 2013; 2016.

Emissions in 2011

GHG emissions estimated from the four categories of waste sector for 2011 are presented in Table 3-28. This includes emissions data for CO_2, CH_4 and N_2O, as well as their CO_2-eq computations.

Table 3-28: GHG Emission from Waste, 2011

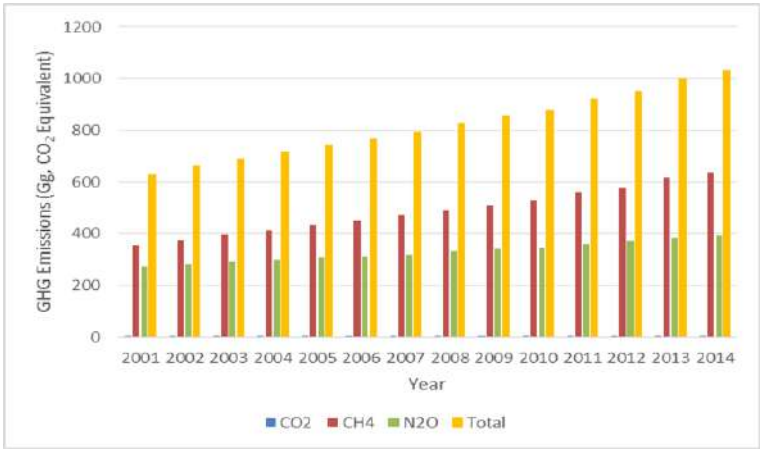
Waste Categories	Emissions [Gg]			Emissions [Gg; CO_2-Eq]			
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
1. Solid Waste Disposal		**10.4633**			**261.5813**		**261.5813**
2. Biological Treatment of Solid Waste		**0.1047**	**0.0063**		**2.6171**	**1.8718**	**4.4889**
3. Open Burning of Waste	**2.3617**	**0.3402**	**0.0061**	**2.3617**	**8.5057**	**1.8250**	**12.6924**
4. Wastewater Treatment and Discharge		**11.4461**	**1.2036**		**286.1522**	**358.6615**	**644.8137**
4a. Domestic Wastewater		**6.9628**	**1.2036**		**174.0689**	**358.6615**	**532.7304**
4b. Industrial Wastewater		**4.4833**			**112.0833**		**112.0833**
Total	**2.3617**	**22.3543**	**1.2160**	**2.3617**	**558.8563**	**362.3583**	**923.5860**

Our estimation shows that, in terms of CO_2 equivalent, Wastewater Treatment and Discharge contributes 70% of total GHG emission. GHG emission from domestic wastewater handling was more than that from industrial wastewater; it is because of low level of industrialization in Nepal. Solid waste disposal contributes 28% of total GHG Emission.

3.7.5. Trend in GHG Emission

The trend of emissions in CH_4, N_2O and CO_2 from waste sector shows a linear growth over the period from 2001 to 2014 (Figure 3-18). The plot shows that CH_4 emission is increasing faster than N_2O and CO_2 emissions. It can be attributed to CH_4 emission associated with solid waste disposal, caused by urban sprawl. CH_4 emission has followed same trend as of population growth. However, slower growth rate of CO_2 and N_2O suggests slow adoption of waste to energy technologies and slower industrial growth.

Figure 3-18: Trend of GHG Emission (CO_2 Equivalent) from Waste Sector, 2001-2014.



3.7.6. GHG Emission Projection

The trend and projection of population and municipal solid waste is presented in Figure 3-19. In business-as-usual scenario, it is assumed that urban individuals will generate same amount of solid waste as in the past. However, there is strong likelihood that per capita waste generation will rise with changing lifestyle.

Figure 3-19: Trend (1991-2011) and Projection (2012-2030) of Urban Population and Solid Waste.

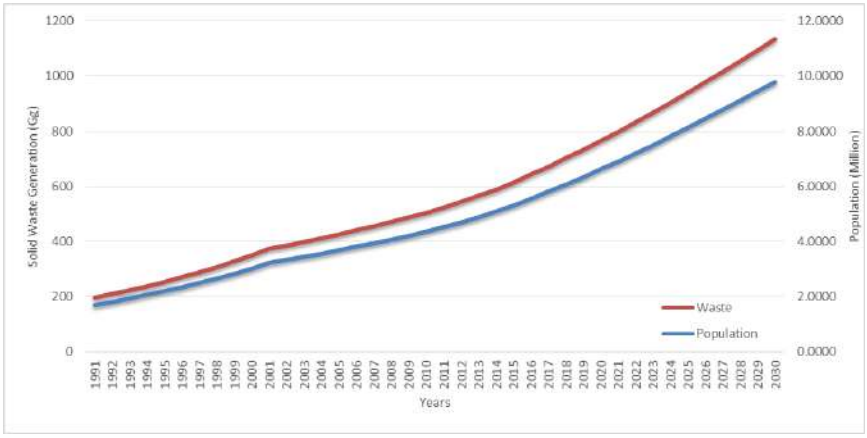
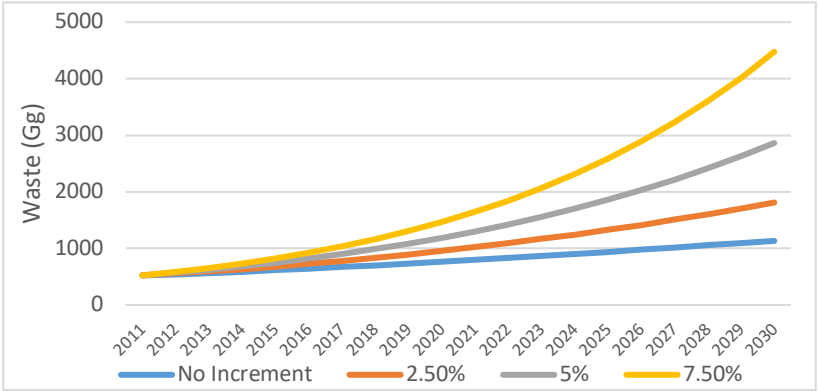


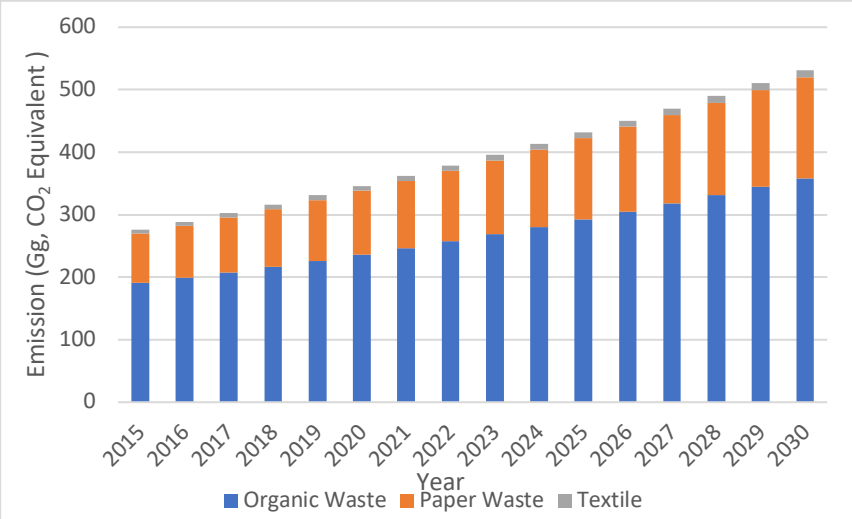
Figure 3-20 presents the projection of waste generation in different rates of increment in per capita waste generation.

Figure 3-20: Waste Generation Projection, 2011-2030



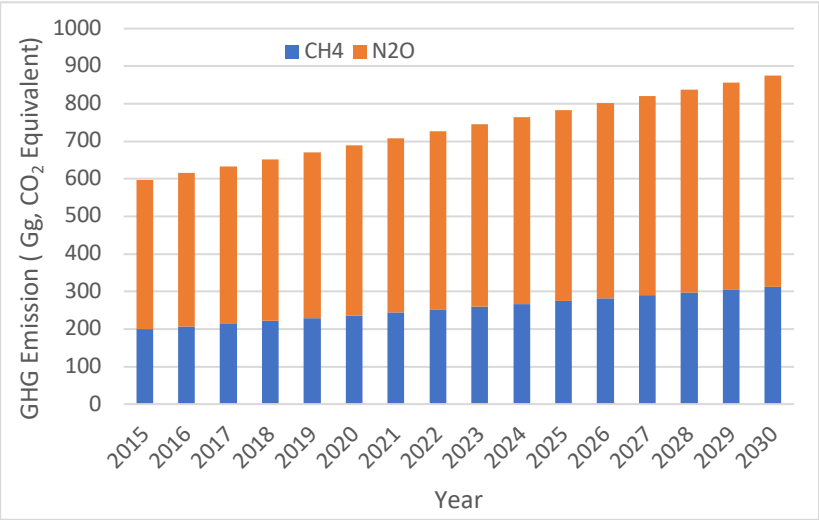
Projections of GHG emission by waste categories may provide greater insights about policy options. For example, Figure 3-21 shows that the biggest emitter of GHG will be organic waste followed by paper waste. CH_4 emission from organic waste can be reduced by encouraging source selection of waste and composting. It can also be reduced by having more biogas plants or by recovering CH_4 from landfill site. Likewise, flaring of CH_4 from landfill site can significantly reduce the emission. Recycling of paper waste will also reduce GHG emission.

Figure 3-21: GHG Emission Projection from different waste Categories.



Similarly, Figure 3-22 shows the projections of CH_4 and N_2O emission from domestic wastewater handling. The increase can be attributed to growing per capita protein consumption.

Figure 3-22: GHG Emission Projection from Domestic Waste Water



4. GREENHOUSE GAS MITIGATION ASSESSMENT

4.1. Introduction

Nepal envisions achieving socio-economic prosperity by building a climate-resilient society. It is formulating a long-term strategy with an aim to achieve net-zero greenhouse gas emission by 2050.This chapter provides a detailed and representative description of the mitigation measures on climate change. The data for this assessment were obtained from the National GHG Inventory 2011 and its projections to 2050. Based on the projections, mitigation options for different sectors, including energy, IPPU, AFOLU, and waste are proposed. The most promising mitigation options in each of the sectors are identified and multi-criteria analysis (MCA) carried out to ascertain the validity of the options. Then, a national action plan has been proposed.

For MCA, eight criteria were identified through literature review and expert consultations (Table 4-1). The experts were asked to rank and give the score for the four sectors (Figure 4-1). Based on criteria and the scores, mitigation options were analyzed through Analytical Hierarchy Process (AHP).

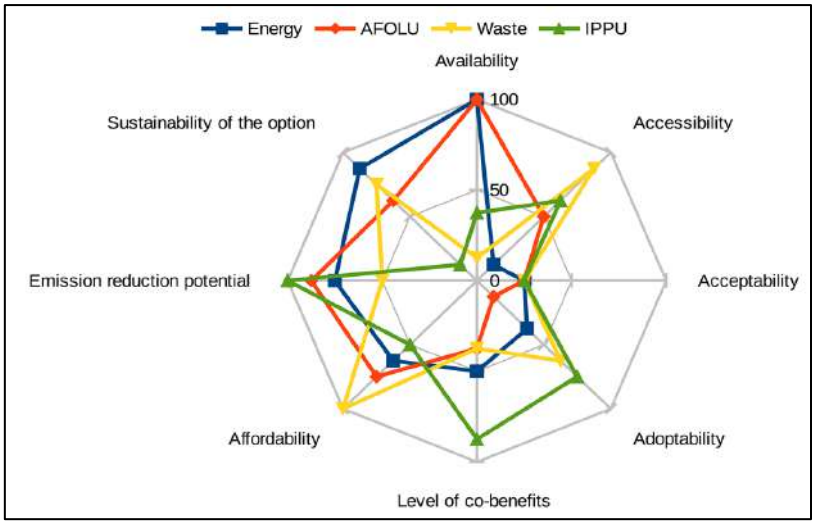
Table 4-1. Criteria for ranking the mitigation options.

S.N.	Criteria
1	Availability (whether the technology is available)
2	Sustainability of the option
3	Emission reduction potential
4	Affordability (mitigation cost and financing requirement of the option)
5	Level of co-benefits
6	Adoptability (technical difficulty and ease of implementation)
7	Acceptability (societal and cultural behavior)
8	Accessibility (including accessibility of the technology)

The figure shows that emission reduction potential and affordability are highly ranked, while acceptability is the least prioritized in most of the sectors. The availability of the technology for implementation received highest priority in Energy and AFOLU sectors. Similarly, emission reduction potential got the highest priority for IPPU. Other criteria received intermediate priorities.

It is essential to note that the availability of technology and other accessories is challenging for Nepal. Similarly, societal and cultural behavior greatly influences the choice of the options, influencing acceptability (IPCC, 2015). Even if acceptability is prioritized the least, it is the critical factor in implementing mitigation options.

Figure 4-1. Ranking of criteria in four sectors



4.2. Sectoral Mitigation Policies

The following paragraphs present mitigation policies and efforts adopted in the four sectors – energy, AFOLU, IPPU and waste.

Energy Sector

While Nepal's energy consumption is growing, it is dominated by biomass (wood, agriculture residues and dung) use. Biomass accounts for 77% of the energy consumption; petroleum accounts for 11%; and coal 4%. While 78% of Nepal's population has access to electricity, its contribution to energy use is very limited. Major policies in the energy sector include those concerned with renewable energy; cleaner transport; and cleaner and efficient cooking (Table 4-2)

Table 4-2. Mitigation policies in energy sector

Policy	Description or Priorities
A. Renewable Energy	
National Climate Change Policy (2019)	• Prioritizes hydropower for low carbon energy. • Emphasizes diversification of energy sources.
Rural Energy Policy (2016)	• Provisions for subsidies and mobilize capital from financial institutions. • Recognizes solar home systems as the main electrification option for many rural households where grid and micro-hydro are not options.
Renewable Energy Subsidy Policy (2016-2030)	• Determines subsidy criteria. • Equally emphasizes credit (at least 30% for projects) and subsidy up to 80% for certain technologies.

Policy	Description or Priorities
National Renewable Energy Framework (2017)	• Allows non-governmental sectors to deliver renewable energy services. • Coordinates stakeholders, mobilizes finance and tracks results from RE initiatives
National Energy Strategy for Nepal (2013-2030)	• Aims to increase energy supply, energy efficiency and domestic clean energy development. • Develop hydropower for multiple purposes and as the lead energy source and build mini-grids in remote areas. • Promote renewable and energy efficient technology. • Explore solar and wind energy potentials. • Promote private investment in hydropower offering loans and subsidies
Nepal's Energy Sector Vision 2050	• Meet national energy demand relying less on petroleum • Prioritizes hydropower and other renewable energy.
White Paper: Current Status and future course of Energy, Hydropower and Irrigation Sector (2018)	• Establish a national carbon market for renewable energy. • Pursue solar and wind energy led irrigation and drinking water projects.
Nepal Electricity Regulatory Commission Bill	• Facilitate electricity production, transmission, distribution, trading and management in a transparent way.
15th National Plan (2019-2024)	• Increase renewable and alternative energy to reduce dependency electricity imported from India. • Achieve fivefold increase in hydropower generation.
B. Cleaner Transport	
National Urban Development Strategy (2017)	• Reduce emissions by improving public transportation • Upgrade provincial road connections • Improve overall connectivity infrastructure and standards.
National Sustainable Transport Strategy (2015-2040)	• Promote the electrification of public transportation • Calls for electric vehicle options in priority tourist destinations.

Policy	Description or Priorities
Environment-Friendly Vehicle and Transport Policy (2014)	• manufacture environment friendly vehicles. • Promote private sector investment in construction and management of EV parking stations and service centers.
National Energy Strategy (2013)	• Promote new transport technology like fuel blending, electric and hybrid vehicles.
Bank Monetary Policy (2017)	• Provides greater loan-to-value ratio for personal electric vehicles (up to 80% versus 65% for fossil fuel vehicles).
National Environmental Policy (2019)	• Reduce air pollution.
15th National Plan (2019-2024)	• Promote electric vehicles.
C. Cleaner and More Efficient Cooking	
Biomass Strategy (2017)	• Replace LPG and kerosene with biomass in cooking. • Improve biomass technology such as ICS, briquettes, biogas plants • Make biodiesel and bioethanol price-competitive through tax exemptions, subsidies and credit facilities. • Preference to locally produced bio-products.
National Energy Strategy of Nepal (2013)	• Promote technologies that improve efficiency of biomass cookstoves. • Promote emerging biomass energy technologies like briquettes, gasifiers, cogeneration and liquid biofuels.
Nepal Environmental Policy (2019)	• Reduce air pollution.
15th National Plan (2019-2024)	• Increase the shares of renewable and alternative energy technology to reduce dependency on fuels such as LPG.

AFOLU Sector

AFOLU is the largest GHG emitting sector. Nepal has adopted a range of policies and measures for mitigation from the AFOLU sector (Table 4-3).

Table 4-3. Mitigation Policies in AFOLU sector.

Policy	Description or Priorities
A. Forestry and Other Land Use	
National Climate Change Policy 2019	• Increase forest carbon sequestration through sustainable forest management. • Mobilize global financial resources through REDD+, Clean Development Mechanism, Green Climate Fund, Global Environment Facility etc.
15th Plan (Fiscal year 2076/77 – 2080/81 B.S.)	• Sustainable management practices and procure global climate finance
National Environmental Policy (2019)	• Tree planting along roads and open spaces.
Forest Policy 2018	• Achieve prosperity through sustainable management of forests, biodiversity and watershed. • Increase carbon stocks for climate change mitigation and generating funds through REDD+.
Agroforestry Policy 2076 BS	• Increase productivity on non-timber forest products under agroforestry and facilitate harvest, transport and sale. • Achieve agricultural commercialization and reduce pressures on forests and biodiversity, maintaining soil quality and protecting the climate.
Land Use Policy 2069 BS	• Maintain forest cover and protected areas, rehabilitate degraded forests and land, and promote green and open urban spaces. • Allocate grazing lands in mountainous areas. • Requires that forest land conversion will need permission from relevant departments.
Rangeland Policy 2068 BS	• Reduce pressures in rangelands from grazing. • Manage rangelands for climate change mitigation, biodiversity conservation and food security.
Forest Sector Strategy	• Seeks to achieve prosperity through sustainable management of forests, biodiversity and watershed. • Recognizes climate change mitigation and resilience as one of the eight pillars of the strategy.
National REDD+ Strategy 2018	• Reduce emissions and enhance carbon stocks by preserving existing forests, rehabilitating degraded ones, increasing reforestation and afforestation efforts, controlling forest fires and sustainably managing forest. • Promote indigenous species; forest-dependent stakeholder engagement; integrated forest, biodiversity and watershed conservation; ecosystem-based adaptation; and participatory ecotourism. • Enhance institutions, policies, management regimes and stakeholder capacity, capability and inclusivity.

Policy	Description or Priorities
Nature Conservation National Strategic Framework for Sustainable Development (2015-2030)	• Integrate nature conservation in sectoral development and planning.
B. Agriculture	
National Climate Change Policy 2076	• Promote low carbon and energy efficient technologies in agriculture and animal husbandry.
15th Plan (FY 2076/77 – 2080/81 B.S.)	• Identify the drivers of GHG emission in agriculture, study its trends and reference level.
National Environmental Policy (2019)	• Expand climate smart agriculture and technology interventions in rural areas.
Agricultural Policy 2061	• Increase food security and rural development. • Preserve environment, natural resources and biodiversity. • Prioritize the development of commercialized agriculture.
Agricultural Mechanization Promotion Policy, 2071	• Increase investment in modern infrastructure and machinery. • Adopt environmentally friendly agriculture machinery.
Irrigation Policy 2070	• Develop reliable, sustainable and environmentally friendly irrigation systems. • Mainstream climate change adaptation and mitigation in irrigation strategies and programs.
Fertilizer Policy 2058	• Meet the demands for chemical fertilizer in agriculture. • Develop integrated nutrient management system.
Agriculture Development Strategy (2015-2035)	• Reduce food insecurity, rural poverty and strengthen the economy.
Nepal's Energy Sector Vision (2050)	• Achieve electrification of water pumping technology. • Achieve electrification of farm machinery.

IPPU Sector

IPPU sector emits the lowest GHG amongst the four sectors. Table 4-4 presents policies and measures for climate change mitigation in the IPPU sector.

Table 4-4. Policies and mitigation measures in IPPU sector

Policy	Description or Priorities
National Climate Change Policy 2076	• Adopt sustainable and low carbon industrial technology. • Develop and adopt mitigation standards after identifying key drivers of industrial sector emission.
15th Plan (Fiscal year 2076/77 – 2080/81 B.S.) (Approach Paper)	• Establish local industries for essential commodities. • Promote 'high value, low volume' products.
Industrial Policy 2011 AD	• Increase industrial output in a sustainable manner.
Nepal's Energy Sector Vision 2050 AD	• Electrification of commercial sector
Nature Conservation Framework for Sustainable Development	• Integrate nature conservation in sectoral development planning and implementation. • Link nature conservation with industrial development and promote green industries.

Waste Sector

Nepal has adopted a range of policies and measures to mitigate GHG emissions from waste sector (Table 4-5).

Table 4-5. Policies and Mitigation Measures in Waste Sector

Policy/Law	Description or Priorities
Solid Waste Management Act (2011)	• Holds waste producers responsible for managing harmful waste. • Empowers local governments to lease land for landfills and to charge fee for waste management. • Allows the private sector in waste management through a transparent bid process.
Climate Change Policy (2019)	• Encourages source segregation of waste and management of harmful and hazardous waste. • Promotes the use of biodegradable waste for energy production.
15th National Plan (2019-2024)	• Emphasizes sustainable waste management. • Promote biogas plants for energy generation and compost and reduction of methane emissions.
National Environmental Policy (2019)	• Promote energy production from waste

4.3. Overall GHG Emission Trends and Projections

The overall trend of GHG emission and its projection to 2050 for each of the four sectors are shown in Figure 4-2 and Figure 4-3, respectively. As the trend of industrial sector is difficult to

ascertain and cement is the most dominant category in IPPU, only the trend of cement production has been shown.

Figure 4-2. Sector-wise GHG emission trend

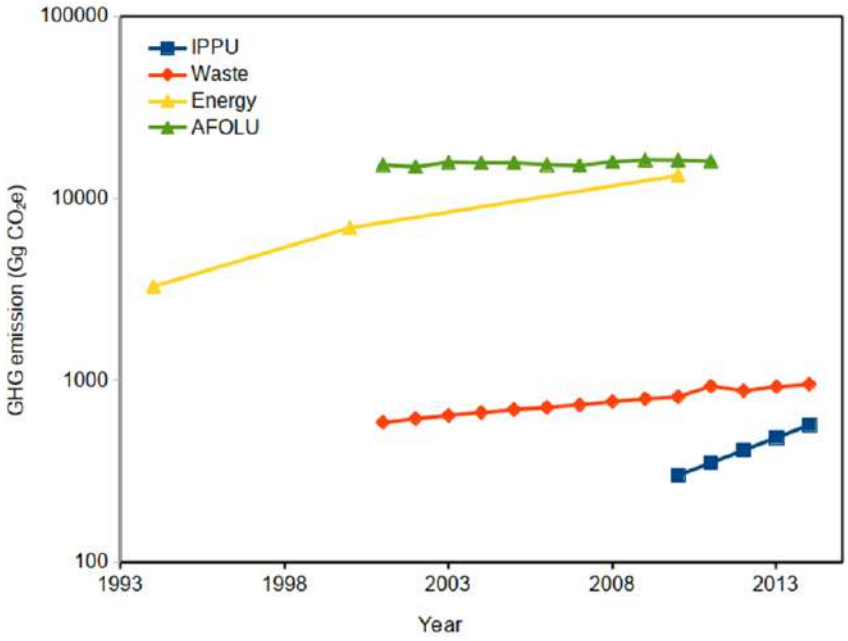
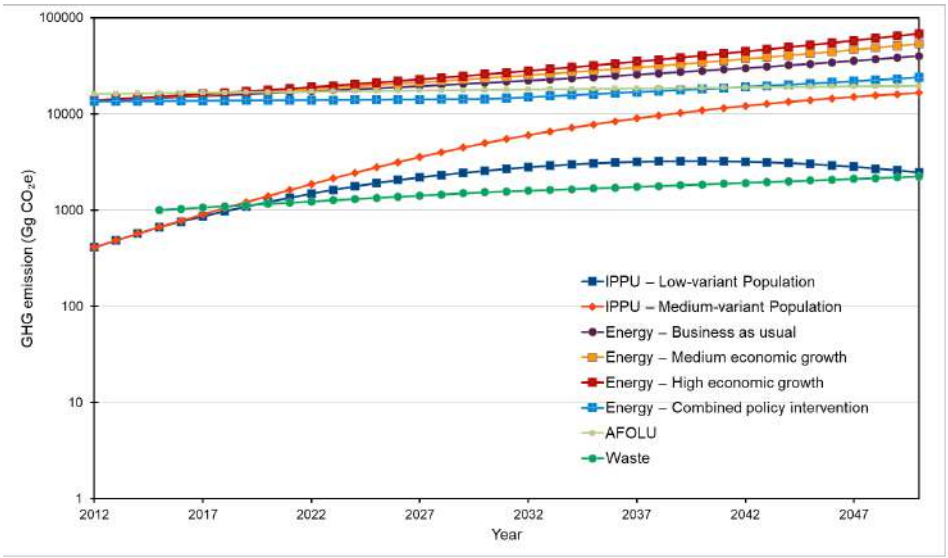


Figure 4-3: The GHG emissions projection for different scenarios



Note: For IPPU sector, only CO_2 from cement production has been considered.

The projection shows that energy sector emission in policy intervention scenario will be comparable to that of AFOLU sector. But, as projected AFOLU emission does not vary significantly, energy sector mitigation policies will significantly affect Nepal's GHG mitigation. The IPPU sector showed a significant increase in the projected GHG emission by 2050. Similarly, assuming that industries will increase in the future, IPPU sector emissions will increase rapidly than that of the AFOLU and Energy sector. Thus, mitigation measures in IPPU sector will be of vital significance.

4.4. Energy sector: Emission Projections, Mitigation Options and Action Plan

4.4.1. Emission Projection in Energy Sector

The following scenarios have been considered for the energy sector (WECS, 2013). The LEAP software was used to make a projection on the energy demand and its emissions (Heaps, 2016):

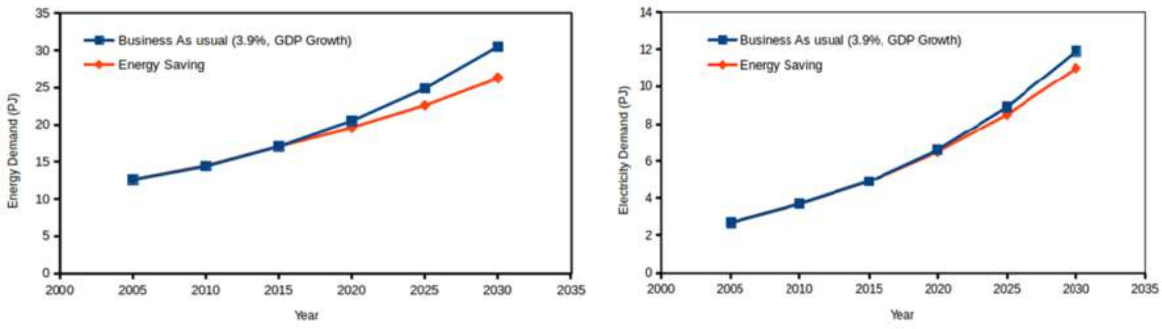
1. Business-as-Usual (BAU): The study assumes an average GDP growth of 4.4% and the shares of each demand technology in energy supply are considered invariant.
2. Medium Growth Scenario: An average GDP growth rate of 5.6% assumed and shares of each demand technology in the energy supply considered invariant.
3. High Growth Scenario: An average GDP growth rate is assumed to be 6.5% and the shares of each demand technology in the energy supply considered invariant.
4. Combined Policy Intervention Scenario: Medium GDP growth rate is assumed to be 5.6%. The interventions considered are:
    i. Replacement of traditional and fossil fuels by clean energy alternatives – electricity, LPG, and ICS.
    ii. Promotion of electrification in all 5 sectors for lighting, heating and other purposes.
    iii. Intervention of more efficient process technologies in industries
    iv. Intervention of mass transportation system
    v. Introduction of new electric and bio-fuel transportation technologies

The GHG projection for energy sector (2010-2030) shows an increase in emissions for all the four scenarios. Emission is projected to be highest for the "high economic growth" scenario, while much lower for "combined policy intervention."

GHG emissions under different scenarios for each sub-sector

Industry: BhatTerai& Bajracharya (2015) show the projection of total energy and electricity demand during the BAU and the energy saving policy scenarios in industry sector (Figure 4-4). It shows that energy demand in 2030 will be 1.78 to 1.53 times of the demand in 2005. Since the changes in demand reflect the changes in GHG emission, demand for energy and consequently for GHG emission can be reduced with the adoption of policy options.

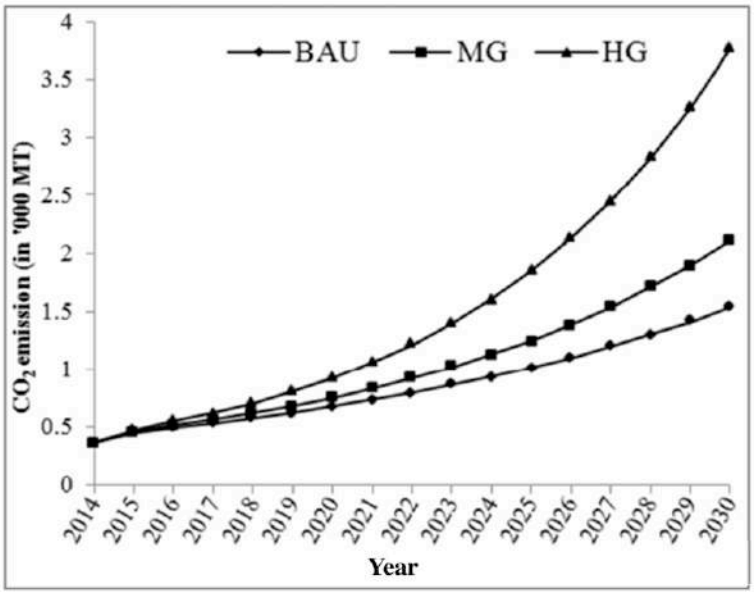
Figure 4-4: Projection of energy and electricity demand, BAU and Energy Saving scenarios



Source: Bhatterai& Bajracharya (2015)

Cement Industry: Singh & Shakya (2016) have formulated policy interventions to reduce energy consumption and mitigate GHG emissions from the cement industry of Nepal (Figure 4-5). In all the scenarios, emissions will increase, but under High Growth scenario, it will be six times greater than for BAU in 2030.

Figure 4-5: CO2 emissions in three scenarios for energy use in Nepal's cement industry



Note: BAU: business-as-usual; MG: medium growth, and HG: high growth scenarios.
Source: Singh and Shakya (2016).

Transport: Table 4-6 presents the scenarios and assumptions in transport electrification in Nepal.

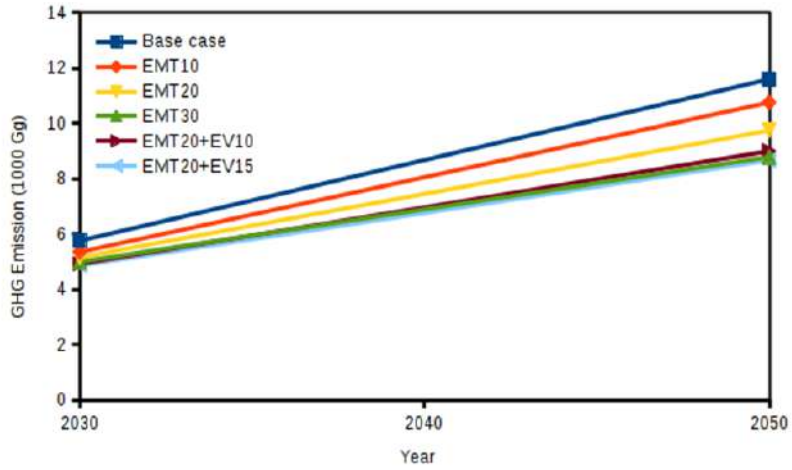
Table 4-6: Transport electrification scenarios and the assumption for each scenario.

S.N.	Scenario	Assumption
1	BAU	The energy system development without any cleaner transport or energy policy restrictions
2	EMT 10	A shift of 10% of the road transport demand to the electric mass transport system from 2020 onwards
3	EMT 20	A shift of 10% of the road transport demand to the electric mass transport system in 2020 and gradually increase the shift to 20% by 2050
4	EMT30	A shift of 10% of the road transport demand to the electric mass transport system in 2020 and gradually increase the shift to 30% by 2050
5	EMT20+EV10	A shift of 20% of the road transport demand to the electric mass transport system and shift of another 10% of the demand to electric vehicles from 2015 onwards
6	EMT20+EV15	A shift of 20% of the road transport demand to the electric mass transport system and shift of another 10% of the demand to electric vehicles in 2015 with gradually increase in the shift of electric vehicles to 15% by 2050

Source: Shakya & Shrestha (2011)

When the transport sector switches its energy from petroleum to electricity, the cumulative GHG emissions of Nepal's transport sector will be decreased by 6.2% and 17.6% under EMT10 scenario and under EMT20+EV15 scenario, respectively during 2005–2050 (Figure 4-6). If the transport sector fully uses clean energy, emissions will decrease significantly (Shakya & Shrestha, 2011).

Figure 4-6: GHG emissions from transport sector under different scenarios.



Source: Shakya & Shrestha (2011)

4.4.2. Mitigation Options for Energy Sector

The multi-criteria analysis (MCA)result on mitigation options in energy sector is shown in Table 4-7. It shows that solar PV systems got the highest rank in energy production followed by roof-top PV systems, solar thermal systems, biogas plants, and wind farming. These options have easy-to-use technologies and received the high priorities. But primary biodiesels, ethanol biodiesel and biodiesel got the low priority.

For energy efficiency, the use of induction lighting and cooking, energy efficient brick kilns, LED lighting got higher priority. Lower priority on improved cookstoves (ICS) can be attributed to rapid urbanization, as urban households use less of ICS. Nevertheless, the use of ICS in rural areas has great potential to mitigate GHG emissions.

In residential sector, electric cooking, advanced lighting systems that include day-lighting and daylight harvesting options got higher priorities. They can ease livelihood of the people and help mitigate GHG emissions. Similarly, in transportation sector, clean energy-based railways, ropeways and cable cars are prioritized over FCV/FCEV and series-hybrid vehicles. However, feasibility studies are need prior to using these options in large scale.

Policy-based climate change mitigation options were also identified for the energy sector. Emission control measures in vehicles got the highest rank followed by energy-saving policies, industrial plant efficiency, mass-transit transport, and eco-driving. For this, users should be encouraged to switch the transport options through tax or other incentive measures. Similarly, cycling is the cleanest means of transportation and reduces the GHG emission. Nepal needs to adopt cycle city policy. For this, Nepal should develop cycle lanes in both old and new roads. It must be further emphasized that the implementation and enforcement of policies related to the control of vehicular emission need greater attention.

Table 4-7. Ranking of mitigation options in Energy Sector

Rank	Energy Production	Energy Efficiency	Residential	Transportation	Policy-based Options in Energy Sector
1	Solar PV Systems	Induction lighting and cooking	Electric cooking	Electric railways	Introducing emission control measures in vehicles
2	Roof-top PV systems	Energy-efficient brick kilns	Advanced lighting systems that include day-lighting and daylight harvesting	Electric ropeways and cable cars	Formulating and implementing energy-saving policies
3	Solar Thermal systems	LED lighting	Building insulation materials	Plug-in hybrid electric vehicle (PHEV)	Increasing industrial plant efficiency
4	Biogas plants	Energy-efficient boilers	Passive house standard	Power-split or series-parallel hybrid vehicles	Developing mass-transit transport systems
5	Wind farming	Energy-efficient furnaces	Advances in digital building automation and control systems	Fuel cell vehicle (FCV) or fuel cell electric vehicle (FCEV)	Promoting eco-driving that consists of vehicle operation that minimizes energy consumption
6	Community biogas plants	Improved Water Mills (IWM)	Electric heating	Series-hybrid vehicles	Promoting cogeneration in industries (both heat (steam) and power)
7	Biomass briquettes	Metal-type (ICS)			Better traffic management, intelligent transport systems, and improved road maintenance
8	Small, Micro and Pico hydropower plants	Mud-type (ICS)			Net metering, smart meters and grids as a means of reducing peak demand and accommodating intermittent renewable electricity sources
9	Primary biofuels				Promoting waste-to-energy technologies
10	Ethanol biofuel				Energy auditing to reduce the amount of energy input into the system (building, process, etc.) without negatively affecting the outputs
11	Biodiesel				Promoting and regulating vehicle maintenance

4.4.3. Energy Sector Mitigation Plan

Mitigation action plan for energy sector is presented in Table 4-8. Renewable and alternative sources have to be promoted in the sector. With good sunshine hours, the installation of solar PV systems, rooftop PV systems and solar thermal systems can be a good option for Nepal. Similarly, biogas production needs to be promoted as energy sources in rural households. Wind energy could also be one of good sources of energy production.

To achieve energy efficiency, induction lighting and cooking have to be promoted. Emissions from brick kilns are significant and hence energy efficient brick kilns, including zigzag brick firing, need to be installed. Energy efficient broilers and furnaces in the industries and powerhouses also help reducing emissions. The promotion of LED bulbs on subsidy basis could enhance the efficiency in lighting. This is consistent with the campaign of 'Bright Nepal, Prosperous Nepal' adopted by the government from FY 2014/15. The installation of solar and micro-hydro for electric cooking, and advanced systems (day-lighting and day-light harvesting) are being promoted in rural households, while in urban areas, hydro energy sources are being promoted.

For transportation sector, the switch to mass transit and promotion of electric railways, ropeways and cable cars are a part of immediate actions. The government has provisioned subsides for the purchase of battery used in electric vehicles. The government has already banned vehicles with age above 20 years and is going to Euro 4 standards. These policies reduce GHGs emissions. Moreover, switch to energy-efficient and new/clean energy vehicles through incentives is an immediate action.

For industrial sector, replacement of fossil fuels by hydro-electricity and other clean energy sources is required. Relocation of enterprises to industrial-business zones and business parks is also required as a long-term action. Promotion of green enterprise and energy efficiency in manufacturing enterprises may also be required.

Table 4-8. Mitigation action plan for energy sector.

Mitigation Options	Actions	Timeline	Responsibility
Solar PV Systems	Policies and financial support for promotion and installation of solar technologies	Short to long term	Provincial government
Roof-top PV systems	Research, policies and financial support for promotion	Long term	Local government
Solar thermal systems	Support for solar thermal energy and heat pumps in residential buildings	Immediate to short term	Central government
Biogas plants	Financial support for promotion and installation of biogas	Immediate	Local government
Wind farming	Research, policies and financial support for promotion of wind energy	Short to long term	Local and provincial government
Community biogas plants	Community empowerment	Long term	Local government
Biomass briquettes	Feasibility studies for bio-briquetting	Immediate	Provincial government
Small, Micro and Pico hydropower plants	Promotion of small hydropower at community level	Immediate	Local government

Mitigation Options	Actions	Timeline	Responsibility
Primary biofuels	Promotion of Biofuels and their efficiency tests	Short to long term	Central government
Ethanol biofuel	Technology intervention	Long term	Central government
Biodiesel	Research and policy support	Short to long term	Central government
Induction lighting and cooking	Subsidies and reliable supply of electricity	Immediate	Local, provincial and central governments
Energy-efficient brick kilns	Scale up of the technology adoption	Immediate	Local government
LED lighting	Aware and cost efficient	Immediate to short term	Central government
Energy-efficient boilers	Policy formulation and access to technology	Long term	Provincial government
Energy-efficient furnaces	Policy formulation and access to technology	Short to long term	Provincial government
Improved Water Mills (IWM)	Subsidy based IWMs in rural settings	Immediate	Local government
Metal-type Improved Cooking Stoves (ICS)	Training and capacity building to install and promote ICS in the areas depending on firewood	Immediate to short term	Local government
Mud-type Improved Cooking Stoves (ICS)	Training and capacity building	Short to long term	Central government
Electric cooking	Promotion of energy-efficient housing construction	Long term	Central government
Advanced lighting systems that include daylighting and daylight harvesting			
Building insulation materials	Housing construction in accordance with the Energy Efficiency Regulation	Short to long term	Central government
Passive house standard	Promotion of the energy renovation of residential buildings	Long term	Central government
Advances in digital building automation and control systems			
Electric heating	Subsidies and reliable supply of electricity	Short term	Provincial government
Electric railways	Introduction of electric vehicles and electric vehicle recharging points; Reshaping of the public transport system	Long term	Central government
Electric ropeways and cable cars	Private sector friendly policy and investment	Short to long term	Provincial government
Plug-in hybrid electric	Incentives for the replacement of private	Short to	Central

Mitigation Options	Actions	Timeline	Responsibility
vehicle (PHEV)	vehicles and promotion of the use of energy-efficient vehicles (vehicles fueled by natural gas and bio-fuels and hybrid vehicles); Reshaping of the public transport system; Urban mobility plans; Linking vehicle taxation to energy efficiency and CO_2 emissions	long term	government
Introducing emission control measures in vehicles	Policies and legal instruments formulation	Immediate to short term	Local, provincial and central governments
Formulating and implementing energy-saving policies			
Increasing industrial plant efficiency			
Developing mass-transit transport systems			
Promoting eco-driving that consists of vehicle operation that minimizes energy consumption			
Promoting cogeneration in industries (both heat (steam) and power)			
Better traffic management, intelligent transport systems, and improved road maintenance			
Net metering, smart meters and grids as a means of reducing peak demand and accommodating intermittent renewable electricity sources			
Promoting waste-to-energy technologies			
Energy auditing to reduce the amount of energy input into the system (building, process, etc.) without negatively affecting the outputs			
Promoting and regulating vehicle maintenance			
Market-based instruments including GHG and energy taxes, cap-and-trade systems and subsidies for			

Mitigation Options	Actions	Timeline	Responsibility
renewable energy			
Regulatory measures such as performance and emission standards			
Switching from fossil fuels to lower-carbon alternative fuels			

Note: Regarding timeline following conventions are considered. Short term: 1-5 years, intermediate/medium term: 6-15 years and long term >15 years.

4.5. IPPU Sector: Emission Projections, Mitigation Options and Action Plan

4.5.1. Emission Projection in IPPU Sector

Cement is the dominant category in Nepal's IPPU sector and contributes over four-fifths of GHG emissions from the sector. The emission for this sector was projected up to the year 2030. The annual growth of 17.3% in cement production is adopted for projecting the emissions. The projection is made for low-variant, medium-variant and high-variant population scenarios (CBS 2014). It shows that cement production emits 4000 to 6000 Gg of CO_2 per annum by 2030.

4.5.2. Mitigation Options for IPPU Sector

Cleaner production, use of alternative raw materials and retrofitting of infrastructure received the highest priorities in IPPU sector, whereas improvement of energy efficiency, replacing high carbon fuels by low carbon fuels, and use of blended cements were prioritized in cement industry (Table 4-9).

Table 4-9. Ranking of mitigation options in IPPU, including cement industry.

Rank	IPPU	Cement
1	Cleaner production	Improvement of the energy efficiency
2	Alternative raw materials	Replacing high carbon fuels by low carbon fuels
3	Retrofitting	Blended cement
4	Electricity for energy in industries	Shifting to a more energy efficient process
5	Resource/mass efficiency	Alternative bricks
6	Energy recovery from sludge and waste	Removal of CO_2 from flue gases
7		Application of alternative cements (e.g., Mineral polymers)
8		Applying lower clinker/cement ratio (increasing the ratio additives/cement): blended cements

4.5.3. IPPU Sector Mitigation Plan

The trend of IPPU sector is difficult to ascertain. The most dominant category in IPPU is cement production, which is the major source of GHG emissions due to energy consumption and its clinker making process. Table 4-10 presents the mitigation action plans for IPPU sector.

Table 4-10: Mitigation action plans for IPPU sector

Mitigation Options	Actions	Key Technologies	Timeline	Responsibility
Cleaner production	Replacing fossil fuel-based sources of energy by cleaner sources of energy like electricity (hydro, wind, solar etc.)	Wind mill, Photo voltaic systems, applying lower clinker/cement ratio (increasing the ratio additives/cement): blended cements, Research, development, and commercial demonstration of new technologies and processes	Long term	Central Government and Provincial government
Alternative raw materials	Substituting fossil fuels (mixing ethanol in fuels, biodiesel)	Application of alternative cements (mineral polymers)	Short to medium term	Central Government and Provincial government
Retrofitting	Blended cement		Immediate	Local Government authorities
Electricity for energy in industries	Adoption of energy efficient lightings	Energy efficient electric motors, pumps, fans, compressors, and boilers and use of LED, CFL fluorescent lamps, Tax incentives for energy efficiency, fuel switching, Emission and efficiency standards	Short to medium term	Provincial Government
Resource/ mass efficiency	Controlling the Cogeneration in industries (both heat (steam) and power, electricity leakages, Energy-saving policies, Metallic Cook Stove (MCS), Smoke hood, use of alternative bricks	Shifting to a more energy efficient process [e.g., from (semi) wet to (semi) dry process], Replacement of high carbon fuels by low carbon fuels	Short to medium term	Industrialists
Energy recovery from sludge and waste	Removal of CO_2 from the flue gases		Immediate to short term	Local Government authorities

Cleaner production includes changes in technology, processes, resources or practices to reduce waste, minimize environmental damage, use resources more efficiently and increase business profitability, ultimately increasing the efficiency of production processes. Some of its techniques include changes in technology, changes in input materials, changes in operating practices, changes in product design, changes in waste use, changes in maintenance, and changes in packaging.

Electricity for energy in industries. Hydroelectricity is the dominant source of energy in industries in spite of enough potential of other cleaner sources of energy like solar energy. Adoptions of energy efficient lightings in industries can also abate excessive consumption of electricity.

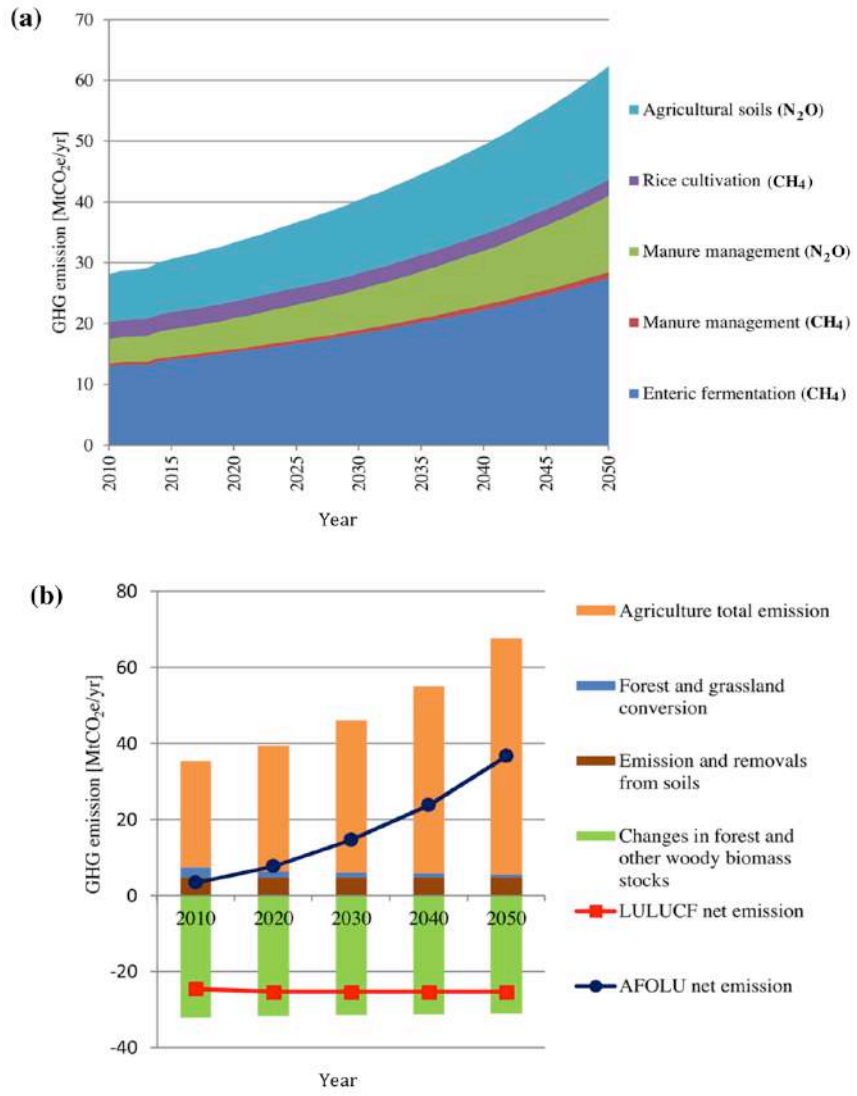
Resource/mass efficiency. There is a huge potential of energy conservation in residential cooking, industrial thermal application and commercial enterprises. It also supports foreign currency savings and energy security. Options include the replacement of diesel-powered electricity generation, cogeneration in industries (both heat and steam), control of electricity leakages, the use of metallic cook stoves, smoke hoods, use of alternative bricks, as well as tax incentives for energy efficient goods and the introduction of emission and efficiency standards.

4.6. AFOLU Sector: Emission Projections, Mitigation Options and Action Plan

4.6.1. Projections for AFOLU Sector

The projections of GHG emission from AFOLU sector and agriculture under BAU scenario for 2011-2050are presented in Figure 4-7. The agricultural GHG emission will be 63 Mt CO_2e in 2050, more than twice that of 2010. The entire AFOLU sector shows a net GHG emission of 3.4 Mt CO_2e in 2010 to 36.7 Mt CO_2e in 2050, which is mostly caused by the increase in agricultural emissions.

Figure 4-7. Projection of GHG emission: (a) Agriculture and (b) AFOLU, 2010–2050, in BAU



Source: Pradhan et al. (2017)

4.6.2. Mitigation Options for AFOLU Sector

Table 4-11identifies and ranks mitigation options for four categories in the AFOLU sector – agriculture, forestry, livestock and land-use. It shows, for example, that *agriculture conservation practices* got the highest priority. Research has shown that conservation agriculture has the potential to reduce the emissions (Sapkota et al., 2014; Aryal et al., 2015). *Adoption of climate-smart technologies* could also mitigate the GHG emissions. Therefore, the government should promote climate friendly agriculture technologies.

Table 4-11. Ranking of mitigation options for AFOLU sector

Rank	Agriculture	Forestry	Livestock	Land-use
1	Agriculture conservation practices	Reducing deforestation	Animal fertility	Grazing lands, plants and animal management
2	Adoption of climate-smart technologies	Afforestation	Enhancing animal productivity	Grazing land fire management
3	Organic farming	Community-based forestry	Rotational grazing	Promotion of protected areas
4	Crop water Management	Agroforestry	Manure management	Control of forest fire
5	Efficient and/or renewable energy in irrigation, food storage and processing	Alternative Energy, Improved Stoves, Private forestry	Stall feeding combined with biogas plant	
6	Development of adaptive varieties	Urban forestry		
7	Vertical farming	Enhancing management of forest resources		
8	Agroforestry			

Similarly, *reducing deforestation* and *afforestation* and reforestation are important mitigation options in forestry. Management of animal fertility and enhancement of animal productivity got the highest priorities in livestock sub-sector. Similarly, management of plants and animals in grazing lands and management of fire in grazing lands got the highest priority in land use sub-sector.

4.6.3. AFOLU Sector Mitigation Plan

Table 4-12 presents the action plans for AFOLU sector. This will be followed by a brief discussion of main options.

Table 4-12: Mitigation action plans for AFOLU

Mitigation Options	Actions	Timeline	Responsibility
Agriculture conservation practices	Mulching, crop residue management, crop rotation by legumes, cover cropping, intercropping, mixed cropping (leguminous species and mustard), crop intensification, farming with perennials	Immediate	Local Government authorities

Mitigation Options	Actions	Timeline	Responsibility
	Minimize N loss from fields, stables and manure storage	Short to medium term	Local Government authorities
	Minimize field crop drying	Immediate and continuing	Local Government authorities
	Increase efficient nitrogen utilization-optimizing crop rotations	Short to medium term	Local Government authorities
	Use crop rotations with a low energy requirement (perennial, N fixing, durable or grazed crops)	Immediate	Local Government authorities
Adoption of climate smart technologies	Encourage capturing and reuse of rain water	Immediate	Local Government authorities
	Reduce pumped irrigation	Immediate	Local Government authorities
	Employ biodiesel and fuel-efficient farm equipment	Medium to Long Term	Local Government authorities
	Dissemination of knowledge and technology of solar based irrigation, drip irrigation, sprinkler irrigation and provision of incentives	Short to medium term	Ministry of Agricultural and Livestock Development
	Formation of a clear organic agriculture development policy	Long Term	Ministry of Agricultural and Livestock Development
	Implementation of organic standards and certification programs	Long Term	Ministry of Agricultural and Livestock Development
Organic farming	Strengthening human resource capacity		Ministry of Agricultural and Livestock Development
	Promote Integrate Pest Management	Immediate	Ministry of Agricultural and Livestock Development
Crop water Management	Dissemination and awareness of System of Rice Intensification (SRI) with Alternate Wetting and Drying (AWD)	Immediate	Local Government authorities
	Give priority to maintenance actions and operation of the installed drainage infrastructure, adoption of water efficient irrigation (e.g., ridge and furrow planting)	Short to medium term	
	Drainage management	Immediate	Local Government

Mitigation Options	Actions	Timeline	Responsibility
		and continuing	authorities
Use of efficient and/or renewable energy (such as solar/wind) in irrigation, food storage and processing)	Provide incentives for using energy efficient techniques in agriculture	Short Term	Local Government authorities
Development of adaptive varieties	Vitalize NARC and its field stations for research, knowledge management and training on climate change	Short to medium term	Local Government authorities
	Adoption of drought resistance and high yielding varieties		Local Government authorities
	Enhance skill of researchers for conducting research on climate change	Immediate and continuing	Local Government authorities
Vertical farming	Protection of urban and peri-urban agricultural zones for enhanced local food production	Immediate and continuing	Local Government authorities
Avoid biomass burning	Conversion of biomass to compost	Immediate	Local Government authorities
Tillage management	Reduced tillage/minimum tillage, zero tillage, no tillage	Immediate	Local Government authorities
Reducing deforestation	Adopt effective forest management techniques or processes	Medium to Long Term	Local Government authorities
Afforestation	Plantation in urban areas	Immediate and continuing	Local Government authorities
	Afforestation in denuded or degraded lands	Immediate and continuing	Local Government authorities
	Conduct forest restoration programs	Immediate and continuing	Local Government authorities
Community-based forestry	Promote collaborative, community and leasehold forestry	Short to medium term	Local Government authorities
Agroforestry	Productive trees plantation in and around crop fields and pastures	Immediate and continuing	Local Government authorities
Urban forestry	Use flood zones productively to mitigate flood risks	Short to medium term	Local Government authorities
	Integrate lots of gardening and small-scale farming in planning by including green space which will facilitate urban agriculture and reduce food miles	Short to medium term	Local Government authorities

Mitigation Options	Actions	Timeline	Responsibility
Grazing lands, plants and animal management	Give priority to the expansion and consolidation of the Program for the Conservation and Protection of Grazing lands	Long Term	Province level ministry
Grazing land-fire management	Give priority to the protection and consolidation of the Program for Conservation and Protection of Grazing lands	Long Term	Province level ministry
Promotion of protected area	Designate areas for new development in clusters adjacent to existing development, such as a local urban district. Avoid policies that enable sprawling, leapfrogging development that requires new road construction and lengthy travel	Long Term	Province level ministry
	Give priority to the protection and consolidation of the Program for the Conservation and Protection of Green Space	Long Term	Province level ministry
Control of forest fire	Protection and consolidation of the Program for the Conservation and Protection of Grazing lands from Forest Fire	Immediate and continuing	Province level ministry
	Enhance human resources capacity for control of forest fire		
Animal fertility	Choice of breed and mating strategies, Early puberty attainment and seasonality, Enhanced fecundity, Nutritional flushing, Enhanced periparturient care and health, Early weaning, Reduction of stressors, Assisted reproductive technologies	Long Term	Local Government authorities
Enhancing animal productivity	Improvements in animal genetics, improving animal health and mortality	Long Term	Province level ministry
Manure management	Diet manipulation, manure storage and separation, Composting, Manure application	Long Term	Local Government authorities
Stall feeding combined with biogas plant		Long Term	Local Government authorities

Agriculture

The agriculture sector of Nepal accounts for around three quarters of employment and one quarter of the country's gross domestic product (MoAD, 2015). In this sector, conservation practices should be modified, and farmers should adopt climate smart technologies like use rain water and use solar energy for pumping water for irrigation, practice organic farming and vertical farming, produce adaptive varieties, mix forestry with agriculture and minimize tillage.

Grazing lands in Nepal are prone to overgrazing and fire so they should be well managed. It is also necessary to increase in fertility and productivity of animals, manage manures, and mix stall-feeding with biogas plant should be practiced.

Agriculture conservation practices: Conservation practices in agriculture constitute the most important option to mitigate agricultural GHG emission. The government should promote mulching, crop residue management, crop rotation, cover cropping, inter-cropping, mixed cropping (leguminous species and mustard), crop intensification, farming with perennials, minimizing nitrogen loss from fields, stables and manure storage by covering the manure with an impermeable sheets, minimize field crop drying, Increase efficient nitrogen utilization-optimizing crop rotations, use crop rotations with a low energy requirement (perennial, N fixing, durable or grazed crops) are few ways that save large amount of CH_4 gas and carbon emissions.

Adoption of climate smart technologies: Climate smart technologies like solar based irrigation, drip irrigation, sprinkler irrigation, capturing and re-use of rain water, use of fossil fuel-efficient farm equipment should be adopted. These practices should also be made part of the 'Prime Minister Agriculture Modernization Project (PMAMP) seeks to develop agriculture as profitable by enhancing the competitiveness of agriculture commodities. Further promotion is also required for solar powered water pumps low-Cost Drip and Micro-Sprinkle Irrigation Technologies, rainwater harvesting. At the same time, knowledge and technology of climate smart technologies should be spread far and wide in the country.

Organic farming: Organic farming should be practiced as a complementary approach. Trainings should be provided to farmers and technicians alike. Clear policy, standards and certification programs for organic agriculture should be developed and implemented.

Crop water Management: Rice is the most important crop and is likely to emit larger amounts of CH_4 in the future. Dissemination and awareness of System of Rice Intensification (SRI) with Alternate Wetting and Drying (AWD), maintaining the installed drainage infrastructure, adoption of water efficient irrigation (e.g., ridge and furrow planting) should be practiced.

Use of efficient and/or renewable energy (such as solar/wind) in irrigation, food storage and processing): The amount of energy used in agriculture is huge since it is used in various forms in numbers of steps. So, efficient and /or renewable energy (derived from wind, water or solar energy) should be used for various agricultural processes. The government should also provide incentives for farmers who use energy efficient techniques.

Development of adaptive varieties (Drought resistance and high yielding varieties): Local varieties are treated as varieties with resistance with various stresses to heat, drought, insects and diseases. Comprehensive breeding strategy to produce seeds with such characteristics along with high yielding capacity will help to tackle the various environmental stresses. NARC and its field stations should be activated more, more researches should be conducted. Farmers should be trained about cropping such species. Farmers should also adopt stress tolerant and high yielding varieties. Skills of researchers should also be enhanced for producing more stress tolerant and high yielding varieties.

Vertical (Roof top) farming: Roof top farming is one of the ways in which urban population can make their resource consumption sustainable. It is possible to produce variety of fruit, grain and vegetable crops on rooftops. Three types of green roofs are: (i) Agricultural green roofs or direct-producing green roofs on which crops are directly grown in (shallow) beds in a soil-

based growing medium that is possibly placed on top of a waterproof membrane or additional layers such as a root barrier, drainage layer and an irrigation system, (ii) Rooftop container gardens or modular green roofs that involve the growing of vegetables, herbs, fruits and flowers in pots, buckets, containers, bottles or raised beds which contain a soil-based growing medium, and (iii) Rooftop hydroponic systems which involve growing plants using water-based nutrient solutions in place of soil. These roofs along with urban and peri-urban agricultural zones can be good medium for enhanced local food production.

Agro-forestry: Agro-forestry is more profitable than forestry alone under some circumstances, and has added benefits for farmers and environment (Amatya, 1999). There is ample scope for introducing agro-forestry in Nepal's community forests as well.

Avoid biomass burning: Farmers burn biomass to reduce the labor costs of preparing their fields for the next crop, but in the process producing smoke, black carbon and GHGs (Pant, 2014). The conversion of biomass to compost should be practiced.

Tillage management: Tillage is a fundamental practice in agricultural management, aimed at creating suitable conditions for the germination of the seeds and the growth of the plant. The mechanical processes increase the porosity of the soil and improve soil structure, with general positive effects, among the others in terms of weed control, water conservation and soil nutrient mineralization, however tillage can possess negative effects like soil erosion, nutrients loss, fuel/energy consumption, and GHG emissions. In particular, tillage causes a loss of soil carbon – and therefore CO_2 – in the atmosphere (Adrian, 2017). Hence, tillage should be either prohibited or minimized to the extent possible.

Forest

The GoN has been promoting programs related to afforestation, community-based forestry, agro-forestry, private forestry and horticulture as well. A new REDD+ program in Nepal is poised to protect about 2.4 million hectares of forests between 2019-2024 with the approval of Nepal's Emissions Reduction Program Document (ERPD) without conditions at the 18th meeting of the FCPF Carbon Fund. The performance-based Emissions Reduction (ER) Program covers 13 contiguous districts of Nepal's Terai Arc Landscape (TAL) with the potential to recover up to US$45 million in lieu of 9 million tons of CO_2e sequestered over a six-year period ending 2024.

Reducing deforestation: Different forest management approaches and expansion of forestry administration have not been fully successful in halting or reversing the deforestation trends in the country. Hence, effective forest management techniques or processes should be carried out; afforestation programs especially in denuded or degraded lands and forest restoration programs should be conducted.

Community-based forestry: Approximately 40% of the total forests come under community forestry. In addition to Community Forests, other community-based forestry like collaborative and leasehold forestry must be promoted to increase the green zones in the country. Private forestry, urban forestry, horticulture promotion programs should be introduced and managed effectively.

Land Use

Grazing lands, plants and animals and fire management: Rangelands are the basis for the livelihoods of local communities. Grazing lands are part and parcel of ecosystem; therefore, programs related to protection of grazing lands from encroachment, over-grazing, and fire should be conducted.

Promotion of protected area: Protected areas of the lowlands and highlands of Nepal comprise huge areas of grasslands, so they should be conserved. Also, local governments should avoid policies that enable sprawling development.

Livestock

Choice of breed and improvement in mating strategies, attention to early puberty attainment and seasonality, enhanced fecundity, nutritional flushing, enhanced peri-parturient care and health, early weaning, reduction of stressors, assisted reproductive technologies should help to reduce emission of GHGs from livestock.

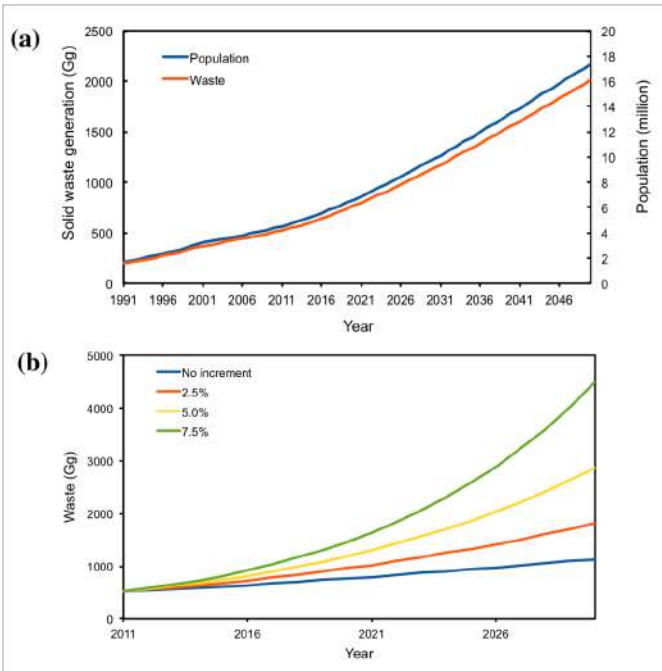
Manure management: Diet manipulation, manure storage and separation, composting of animal waste and manure application in fields also help to cut off GHGs emission. In addition, the combination of stall feeding with biogas plant is also beneficial to reduce GHG emission.

4.7. Waste Sector: Emission Projections, Mitigation Options and Action Plan

4.7.1. Emission Projection in Waste Sector

In BAU scenario, urban population is assumed to generate same amount of solid waste per capita; though it is likely that per capita waste generation will rise with changing lifestyle. Figure 4-8 shows a) trend and projection of solid waste, and b) projection of waste generation projection until 2050. Assuming a growth rate of 5% on per capita waste generation, solid waste generation is expected to double by 2030.

Figure 4-8: Trends (1991-2011) and projections (2012-2050) for waste sector



Notes: (a) Urban population and solid waste; and (b) Waste generation projection with different increment in per capita waste generation.

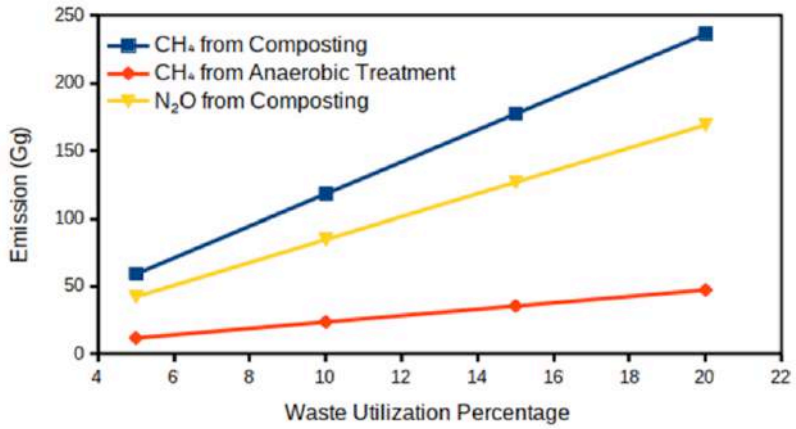
Anaerobic treatment of solid waste produces biogas that is predominantly CH_4. During anaerobic decomposition, CH_4 is generated while N_2O is insignificant.

Similarly, four scenarios of composting have been considered while projecting emissions from waste:

- 5% of waste composted
- 10% of waste composted
- 15% of waste composted
- 20% of waste composted

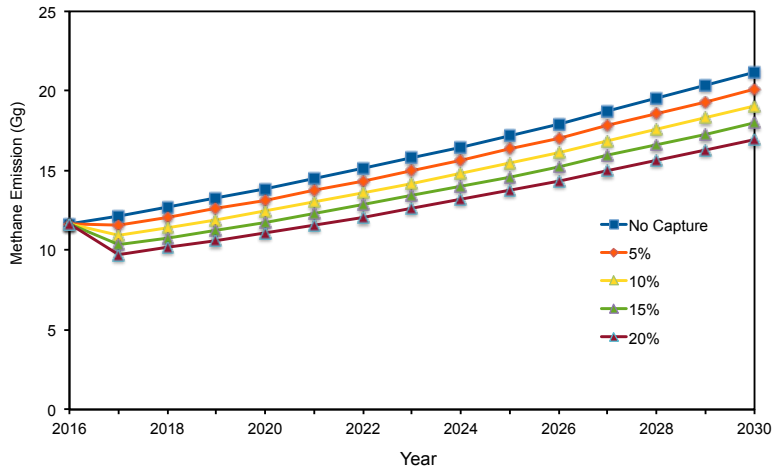
CH_4 emission from composting is many-folds higher than that of biogas (Figure 4-9). But, N_2O generated from biogas is insignificant.

Figure 4-9. Cumulative GHG Emission (Gg) from Composting and Biogas



Landfill sites emit a large amount of CH_4 every year. Introducing carbon-capturing technologies can significantly reduce CH_4 emission. Three scenarios have been considered: Business as Usual (BAU) with 5% methane capture, 10% methane capture, and 20% methane capture, starting from 2018. The projected CH_4 emissions with different scenarios are presented in Figure 4-10. By 2030, 5.84, 11.68, and 23.36 Gg of CH_4 will be emitted with 5%, 10%, and 20% methane capture scenarios, respectively.

Figure 4-10. Projection of CH4 Emission from Landfill Sites



4.7.2. Mitigation Options for Waste Sector

The mitigation options for waste sector of Nepal are identified and prioritized in Table 4-13. Open burning of waste is the major source of GHG emission in the country. Thus, the *reducing/controlling open burning of waste* received the highest priority, followed by *reducing landfilling*. On the other hand, use of advanced technologies, like incineration and industrial co-combustion and landfill gas recovery got the lowest priority. However, these options are also important in mitigating the GHG emissions in the sector (Bogner et al., 2008).

Table 4-13. Ranking of mitigation options for Waste Sector.

Rank	Mitigation Options
1	Reduce/control open burning of waste
2	Reduce land-filling
3	Engineered and non-engineered wastewater management
4	Post-consumer recycling
5	Composting
6	Anaerobic digestion
7	Waste technologies (incineration and industrial co-combustion)
8	Landfill gas recovery

4.7.3. Waste Sector Mitigation Plan

Open burning of solid waste, unscientific land filling, inefficient waste water treatment and inadequate post-consumer recycling and insufficient composting lead to emission of GHGs from Nepal's waste sector. To reduce emissions from waste, an action plan is prepared and presented in Table 4-14.

Table 4-14: Mitigation action plans for waste sector

Mitigation Options	Actions	Timeline	Responsibility
Reduce/control open burning of waste	Education focusing on disastrous effect of burning waste and high cost for government and individual to treat illness	Immediate	Local Gov
	Waste to energy technologies including plasma arc technology, refuse derived fuels (RDF) and solid refuse fuel SRF)	Short to long term	Provincial Authorities
	Expansion of recycling infrastructures and facilities; Single and dual stream recycling plants are recommended technologies	Long term	Local Government
	Composting of degradable waste that are burned	Immediate	Local Gov
	Improved collection to reduce residential waste burning and improved dumpsites to reduce open burning at dumpsites; Scientific land filling technologies are recommended	Short to long term	Local Government
Engineered and non-engineered wastewater management	Construction of smaller wastewater treatment plants with reduced nutrient loads and proportionally lower GHG emissions; Improved engineering technologies are recommended	Medium to long term	Provincial Authorities
	Low-water-use toilets and ecological sanitation approaches (including ecological toilets) where nutrients are safely recycled into productive agriculture and environment	Short to long term	Local Government
	Recycling of bio solids; the organic byproduct of the treatment process for agricultural and forestry uses; Sludge recycling technologies are recommended	Long term	Provincial Authorities
	Providing opportunities to reuse highly-treated water from the plants; Engineered waste water treatment plants are recommended technologies	Long term	Local Government
Post-consumer recycling	Legislative promotion and imposition, research on appropriate technologies for recycling	Immediate	Provincial Gov
	Preparation of a complete recovery and recycling plan, assessment of markets for recyclables	Immediate to short term	Local Government
	Establishment of recycling plants for end-of-life tires and batteries; Heavy metal (e.g., Lead, Pb) recycling technologies are recommended	Short to long term	Provincial Authorities
Composting	Promotion of vermin-composting	Immediate	Local Gov
Anaerobic digestion	Promotion of anaerobic digestion technologies that capture CH_4 from manure which might otherwise be released into the atmosphere as a potent GHGs	Short to long term	Local Government
Landfill gas recovery	Shifting from conventional to engineered landfill gas recovery system (Controlled landfill bioreactor, permeable layers to improve LFG recovery, use of subsurface gas probes, methods to overcome water-logging that can impede gas extraction); Engineered landfill gas recovery systems are recommended technologies	Long term	Provincial Authorities

4.8. Key Changes from Second National Communication

With the updated GHG emission scenarios and the availability of more novel technologies, several new action plans for mitigation of the impacts of climate change in Nepal have been proposed in this report (Table 4-15).

Table 4-15: Key changes from SNC in TNC

Action Plans in SNC	Proposed Action Plans
Residential (Energy)	
Develop energy efficiency standards. Financial supports to upgrade existing homes or build new homes to meet standards.	Policies and financial support for promotion and installation of alternative energy like solar, wind, micro-hydro, ICS and biogas etc.
Develop Leadership in Energy and Environmental Design (LEED) certified energy efficiency standards for new or renovated commercial and institutional buildings.	Housing construction in accordance with the Energy Efficiency Regulation
Develop policies for promotion of renewable energy (e.g., wind, solar and hydropower)	Promotion of energy-efficient housing construction
	Support for solar thermal energy and heat pumps in residential buildings
Transportation (Energy)	
Encourage purchase of fuel-efficient vehicles as well as promote public and active modes of transportation	Reshaping of the public transport system
Upgrade and effectively implement Vehicle and Transport Management Act 1993 and Nepal Vehicle Mass Emission Standard 1999 which is clarified as similar to Euro-1 standard to Euro-3 standard	Urban mobility plans
Conduct vehicles test through ultra-modern equipment from Vehicle Fitness Test Centre (VFTC)	Incentives for the replacement of private vehicles and promotion of the use of energy-efficient vehicles (vehicles fueled by natural gas and bio-fuels and hybrid vehicles)
Formulate new National Transportation (Vehicle) Policy which will encourage to import and manufacture environment friendly and low pollutant vehicles in Nepal	Eco-labeling – Energy label for cars
	Linking vehicle taxation to energy efficiency and CO2 emissions
	Introduction of electric vehicles and electric vehicle recharging points
Industrial (Energy)	
Develop hydropower projects. Subsidize use of hydro-electricity and other green energies for gradual replacement of the use of fossil fuels	Assist gradual replacement of the use of fossil fuels through subsidizing use of hydro-electricity and other sources of green energies
	Relocation of enterprises to industrial-business zones and business parks
	Support for improving energy efficiency in manufacturing enterprises
	Promotion of Green Enterprise
	Support for solar thermal energy and heat pumps

Action Plans in SNC	Proposed Action Plans
	in residential buildings
Waste	
Support municipalities in incorporating solid waste management related programs and actions in the annual plan and budget.	Preparation of a complete recovery and recycling plan, assessment of markets for recyclables and establishment of recycling plants for end-of-life tires and batteries
Develop code of practices for waste management, promulgation of bylaws, directives.	Adoption of integrated waste management practices that involve waste reduction at the source, resource recovery and recycling (Developing meaningful partnership with private and informal sectors)
Promote municipal/community composting as well as household composting of organic wastes	Community based composting to convert organic waste to resources and generate carbon credits
Ensure financial sustainability by enhancing efficiency and promoting cost recovery mechanism	Shifting from conventional to engineered landfill gas recovery system (Controlled landfill bioreactor, use of subsurface gas probes, and methods to overcome water logging
Develop landfill sites with CH_4 recovery facilities	Construction of smaller wastewater treatment plants with reduced nutrient loads and proportionally lower GHG emissions
IPPU	
Prepare rules for industries to conduct energy and environment audits	Controlling the Cogeneration in industries (both heat (steam) and power) electricity leakages, Energy-saving policies, Metallic Cook Stove (MCS), Smoke hood
Conduct efficient monitoring of national efficiency standards	Use of energy efficient lightings
Conduct life cycle analysis to display carbon emission-footprints	Replacing fossil fuel-based sources of energy by cleaner sources of energy like electricity (hydro, wind, solar etc.)
Implement Environment Management System (EMS) in all industries	Substituting fossil fuels (mixing ethanol in fuels, biodiesel)
Agriculture	
Prepare guidelines for farmers that include livestock management	Choice of breed and mating strategies, Early puberty attainment and seasonality, Enhanced fecundity, Nutritional flushing, Enhanced peri-parturient care and health, Early weaning, Reduction of stressors, Assisted reproductive technologies
Establish farmers' cooperatives that will, among others, oversee proper utilization of forage resources through monitoring of stock numbers, grazing duration and grazing time, nutrient management and shrub and weed control	Improvements in animal genetics, improving animal health and mortality
	Diet manipulation, manure storage and separation, Composting, Manure application
	Mulching, crop residue management, crop rotation by legumes, cover cropping,

Action Plans in SNC	Proposed Action Plans
	intercropping, mixed cropping (leguminous species and mustard), crop intensification, farming with perennials
	Minimize N loss from fields, stables and manure storage by covering the manure with an impermeable sheet
	Minimize field crop drying
	Increase efficient nitrogen utilization-optimizing crop rotations
	Use crop rotations with a low energy requirement (perennial, N fixing, durable or grazed crops)
	Encourage capturing and re-use of rain water
	Reduce pumped irrigation
	Employ biodiesel and fuel-efficient farm equipment
	Dissemination of knowledge and technology of solar based irrigation, drip irrigation, sprinkler irrigation and provision of incentives
	Formation of a clear organic agriculture development policy
	Implementation of organic standards and certification programs
	Strengthening human resource capacity
	Promote Integrate Pest Management
	Dissemination and awareness of System of Rice Intensification (SRI) with Alternate Wetting and Drying (AWD)
	Give priority to maintenance actions and operation of the installed drainage infrastructure, adoption of water efficient irrigation (e.g., ridge and furrow planting)
	Drainage management
	Provide incentives for using energy efficient techniques in agriculture
	Vitalize NARC and its field stations for research, knowledge management and training on climate change
	Adoption of drought resistance and high yielding varieties
	Enhance skill of researchers for conducting research on climate change
	Conversion of biomass to compost
	Reduced tillage/minimum tillage, zero tillage, no tillage

Action Plans in SNC	Proposed Action Plans
Land Use, Land Use Change and Forest	
Restore degraded lands through forestation (e.g., promotion of community forest and lease fore	Afforestation in denuded or degraded lands, Plantation in urban areas
	Conduct forest restoration programs
	Adopt effective forest management techniques or processes
	Give priority to the expansion and consolidation of the Program for the Conservation and Protection of Grazing lands
	Give priority to the protection and consolidation of the Program for the Conservation and Protection of Grazing lands
	Designate areas for new development in clusters adjacent to existing development, such as a local urban district. Avoid policies that enable sprawling, leapfrogging development that requires new road construction and lengthy travel
	Give priority to the protection and consolidation of the Program for the Conservation and Protection of Green Space
	Protection and consolidation of the Program for the Conservation and Protection of Grazing lands from Forest Fire
	Enhance human resources capacity for control of forest fire
	Give priority to the protection and consolidation of the Program for the Conservation and Protection of Green Space
	Promote collaborative, community and leasehold forestry
	Productive trees plantation in and around crop fields and pastures
	Use flood zones productively to mitigate flood risks
	Integrate lots of gardening and small-scale farming in planning by including green space which will facilitate urban agriculture and reduce food miles

5. VULNERABILITY, IMPACT AND ADAPTATION ASSESSMENT

5.1. Introduction

Nepal is ranked as one of the most vulnerable countries to climate change and has been facing vulnerabilities in several aspects of people's lives and livelihoods as well as on their environment. The IPCC fifth assessment defines vulnerability as the propensity or predisposition to be adversely affected and it encompasses the sensitivity or susceptibility to harm and lack of capability to cope and adapt (Oppenheimer et al., 2014). Accordingly, there has been a considerable emphasis on adaptation, in view of the country's climatic trends and socio-economic conditions characterised by high levels of poverty, marginalisation and destitution.

This chapter provides a detailed and representative description of the climate change Vulnerability, Impacts, and Adaptation (VIA) assessment of Nepal. The next section presents the approach and methods employed in this VIA assessment. The assessment was guided by IPCC Guidelines and deployed analysis of climate trends and projections; carried out scenario analysis and used different methods for sector-wise vulnerability assessment and adaptation measures. It then identifies eight sectors impacted by climate change, and presents the analysis of vulnerability impacts and assessment of adaptation measures in each. It then presents the summary of impacts for all sectors. The chapter then moves to outline policies, laws, plans and activities as a sum of "Programmes containing measures to facilitate adaptation to climate change" in accordance with the IPCC guidelines. Finally, it presents the Adaptation Plans for eight sectors and their tentative time horizons and cost sizes.

5.2. Approaches and Methodology

For the National Adaptation Plan (NAP) process, two main studies were carried out: Observed Climate Trends in Nepal (1971-2014) (DHM, 2017) and Climate Change Scenarios for Nepal (MoFE, 2018). They improved their methodology from the one in SNC and offered an updated understanding on the past and future climate in Nepal. In addition to them, this report considered other studies as the main source of information.

DHM (2017) provides data and information on climate normal, climate trends, precipitation and temperature trends from 1971 to 2014 for districts and physiographic regions of Nepal. Temperature and preparation data are used from the ground stations. For temperature analysis, daily temperature data from 93 meteorological stations were used. For precipitation analysis, 0.05-degree Asian Precipitation Highly-Resolved Observational Data Integration towards Evaluation (APHRODITE) daily gridded data were used (Andermann et al., 2014; Yatagai et al., 2009). The methodology for quality checking and interpolation was provided by Yatagai et al. (2012).

This assessment considers two Representative Concentration Pathways (RCPs): RCP4.5 and RCP8.5. Climate scenarios for temperature (mean, maximum, and minimum) and precipitation were developed for the whole of Nepal at 10 km resolution. The climate scenarios were developed for two future periods (medium-term: 2016-2045; long-term: 2036-2065) with reference period of 1981-2010. In addition, the period of 2071-2100 was considered to understand how the climate might change by the end of the century. The projection was used while identifying adaptation options.

In 2010, Nepal prepared the vulnerability map of Nepal (MoE 2010). In the ongoing preparation of NAP, the GoN developed vulnerability and risk assessment framework and indicators. It identified the sectoral indicators and data sources in the country (MoPE 2017a).

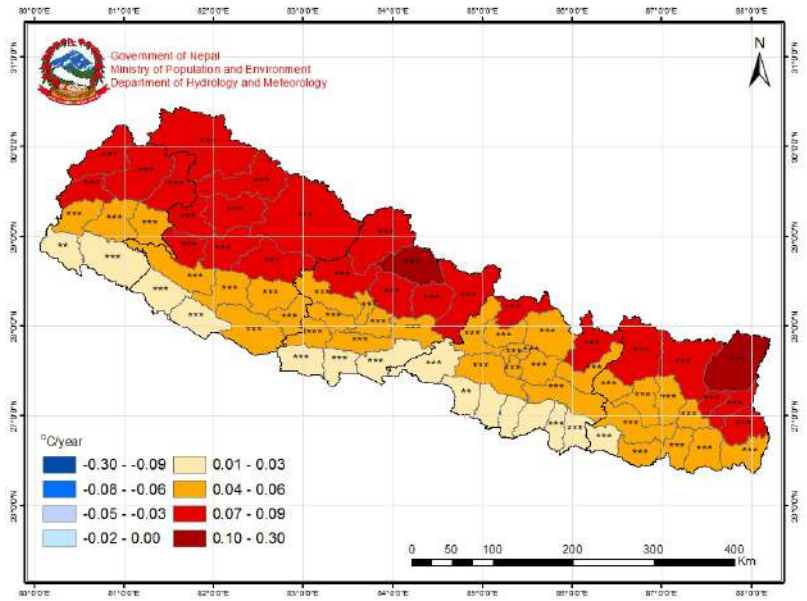
5.3. Climatic Trends and Scenarios of Nepal

5.3.1. Climatic Trends—Temperature and Precipitation

a. Temperature

DHM (2017) provides data on the trends in maximum and minimum temperatures in districts and physiographic regions of Nepal. All-Nepal annual maximum temperature shows positive trend of 0.056 °C yr^{-1} significant at 99.99% (Figure 5-1). Most of the districts (80%) showed positive trends of annual maximum temperature higher than 0.04 °C yr^{-1}. The magnitude of the positive trend is high in the mountain districts than the lower elevation districts. This pattern is evident also in all the seasons (e.g., the highest trend of 0.12 °C yr^{-1} is observed in Manang in winter) and is more evident in monsoon season (DHM, 2017). Moreover, this is clear among five physiographic regions: the Terai has the lowest positive trend (0.036 °C yr^{-1}) and the High Himalaya has the highest positive trend (0.072 °C yr^{-1}).

Figure 5-1: Annual maximum temperature trends in the districts of Nepal



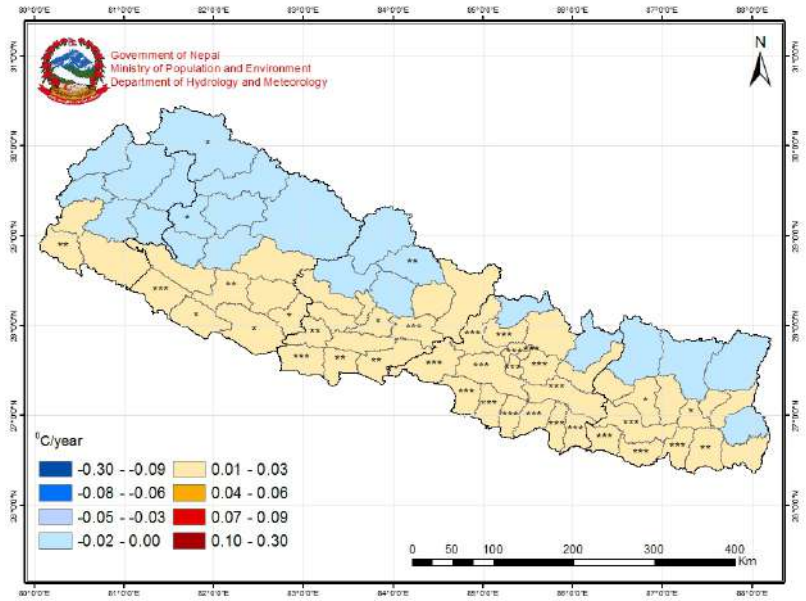
Note: Significance: * 95% CL, ** 99% CL, *** is 99.9% CL; blank means insignificant at 95% CL.

Studies show that the greatest amount of warming is seen in the mountain stations (Thakuri et al., 2019; Kattel & Yao, 2013; Baidya et al., 2008). Some of the Terai districts showed decreasing maximum temperature trend, but statistically insignificant, mainly during winter and pre-monsoon seasons. This pattern is associated with long duration fog episodes observed since the last decade. Therefore, this trend in the Terai cannot be ignored even though it is not statistically significant.

DHM (2017) has also produced annual and seasonal minimum temperature trends for districts and physiographic regions (Figure 5-2). All-Nepal minimum temperature trend is 0.002 °C/yr, but not significant even at 95% confidence. Annual minimum temperature showed a positive trend in low elevation districts and negative in high elevation districts. Minimum temperature in Terai showed the highest positive trend (0.025 °C yr^{-1}) in winter while High Himalaya and

High Mountain showed the lowest increasing trend (0.013 °C yr^{-1}) during monsoon. However, minimum temperature signals are not as robust as that of the maximum temperature.

Figure 5-2: Annual minimum temperature trends in the districts of Nepal

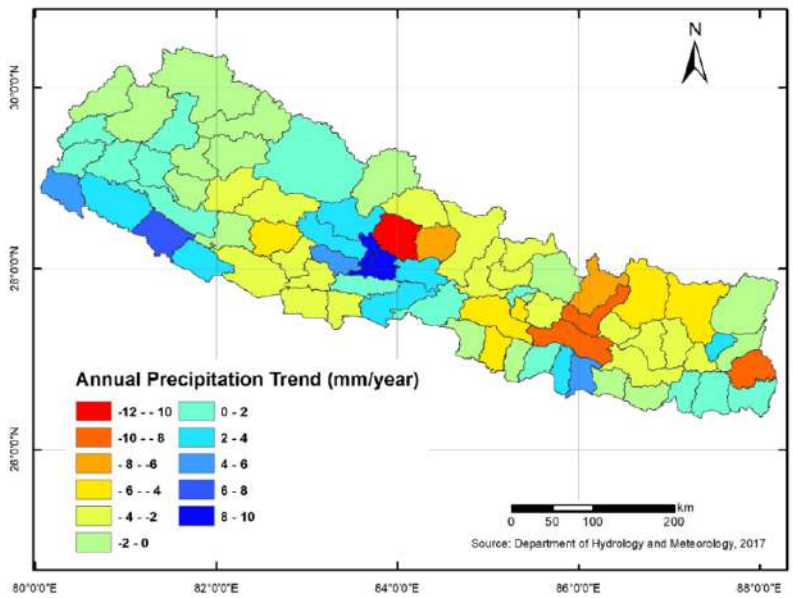


Note: Significance: * 95% CL, ** 99% CL, *** is 99.9% CL; blank means insignificant at 95% CL; Source: DHM (2017).

b. Precipitation

DHM (2017) further provides trends in seasonal and annual precipitation (Figure 5-3). In most of High Mountain districts, annual precipitation is decreasing, with a higher rate in the east. Precipitation is in decreasing trend mainly in High Mountains and High Himalayas during all seasons (DHM, 2017). In monsoon, the highest significant increasing precipitation trend (9.0 mm yr^{-1}) is found in Syangja district and decreasing trend (-7.5 mm yr^{-1}) in Ilam (DHM, 2017). Winter precipitation is increasing in the Terai, Chure (Siwalik), and Middle Mountains while it is decreasing in High Mountains and Himalayas.

Figure 5-3: Annual precipitation trend in districts of Nepal



Source: DHM (2017)

c. Extreme Climate Trends

DHM (2017) has further identified 11 climate extreme indices, of which six are extreme temperature indices and five are extreme precipitation indices (Table 5-1). Extreme temperature trends showed more robust signal than for extreme precipitation. Warm days, warm nights and warm spell duration are increasing and cool days are decreasing significantly in most districts, while cool nights and cold spell durations showed mixed signal.

Table 5-1: Extreme climate trends in Nepal based on observed data 1971-2014

	Extreme Climate Indices (Description)	Trend pattern/regions
Extreme Temperature Indices	1. Warm days (Percentage of days when maximum temperature >90th percentile)	
	2. Warm nights (Percentage of days when minimum temperature >90th percentile)	• increasing in majority of districts
	3. Warm spell duration (Annual count of days with at least 6 consecutive days when maximum temperature > 90th percentile)	
	4. Cool days (Percentage of days when maximum temperature <10th percentile)	• decreasing in majority of the districts
	5. Cool nights (Percentage of days when minimum temperature >90th percentile)	• increasing significantly (northwest) • decreasing significantly (southeast)
	6. Cold spell duration (Annual count of days with at least 6 consecutive days when minimum temperature < 10th percentile)	• increasing significantly only in the Far-western districts • Insignificant trends in other districts
Extreme Precipitation Indices	1. Number of rainy days (Annual count of days with daily precipitation > 1mm)	• increasing significantly in the north-western districts
	2. Very wet days (Annual total precipitation when daily rainfall >95th percentile)	
	3. Extremely wet days (Annual total precipitation when daily max rainfall >99th percentile)	• decreasing significantly, mainly in the northern and mountain districts
	4. Consecutive wet days (Maximum number of consecutive days with daily precipitation >1mm)	• Increasing significantly in the northern districts of Karnali Province and central part of Gandaki Province and Province 1.
	5. Consecutive dry days (Maximum number of consecutive days with daily precipitation <1mm)	• decreasing significantly, mainly in the north-western districts

Source: DHM (2017)

5.3.2. Climate Change Projections- Temperature and Precipitation

The changes in temperature and precipitation were projected for medium term (2016-2045), long term (2036-2065) and "end of the century" with the reference period of 1981-2010.

a. Temperature Projection

Table 5-2 presents the range of mean temperature changes for three time periods with respect to the reference period for different seasons. Mean annual temperature increase ranges from 0.92 to 1.07 °C in the medium-term and 1.3 to 1.8 °C in the long-term and even higher rate at the end of the century. The highest temperature increase is projected for the post-monsoon season for medium-term and long-term periods.

Table 5-2: Projected range of multi-model ensemble mean change in temperature (°C) of Nepal for different seasons in three time periods with respect to reference period

Seasons	Medium-term (2016-2045)		Long-term (2036-2065)		End of the Century 2071 – 2100	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Winter	1.0	1.2	1.5	2.0	2.1	4.0
Pre-monsoon	0.7	1.0	1.0	1.6	1.2	3.4
Monsoon	0.8	0.8	1.1	1.5	1.4	3.0
Post-monsoon	1.3	1.4	1.8	2.4	2.5	4.5
Annual	0.92	1.07	1.3	1.8	1.72	3.58

Source: MoFE (2018)

The ranges of mean annual temperature projection for physiographic regions are shown in Table 5-3. Under RCP4.5, the highest temperature increase is in the High Mountains for all three periods. Under RCP8.5, the temperature increase is maximum in the Terai and then in the High Mountains. The annual mean temperature is projected to increase by 0.95 °C in medium-term and 1.36 °C in long-term in RCP4.5 for the High Mountains and by 1.11 °C in medium-term and 1.87 °C in long-term in RCP8.5 for Terai.

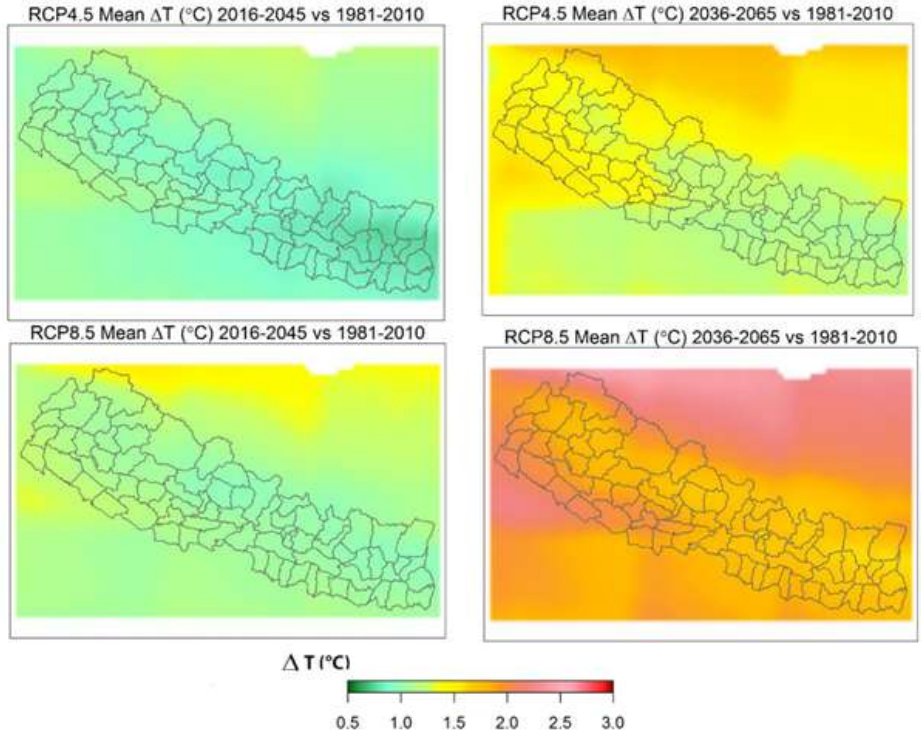
Table 5-3: Projected range of multi-model ensemble mean change in temperature (°C) with respect to reference period

Physiographic regions	Medium-term (2016-2045)		Long-term (2036-2065)		End of the Century 2071 – 2100	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
High Mountain	0.95	1.09	1.36	1.86	1.79	3.61
Middle Mountain	0.89	1.04	1.27	1.76	1.66	3.44
Hill	0.9	1.06	1.26	1.8	1.69	3.56
Siwalik	0.94	1.1	1.29	1.87	1.72	3.66
Terai	0.93	1.11	1.29	1.87	1.73	3.69

Source: MoFE (2018)

Moreover, spatial pattern of projected changes in mean annual temperature is shown in Figure 5-4 for medium term and long-term periods.

Figure 5-4: Multi-model ensemble mean changes in average annual mean temperature



Source: MoFE (2018)

Note: Developed for medium-term (2016-2045) and the long-term (2036-2065) with respect to the reference period (1981-2010) for RCP4.5 and RCP8.5.

b. Precipitation Scenarios

Table 5-4 presents the range of mean precipitation changes for the medium-term, long-term and end of the century with respect to the reference period for different seasons. Annual, monsoonal and post monsoon precipitation projections showed an increase in precipitation while pre-monsoon precipitation is projected to decrease, except for RCP8.5 in the long-term period. Winter precipitation is projected to increase in the long-term and at the end of the century. Maximum precipitation increase is observed during the post-monsoon season followed by the monsoon season. The end of the century period also suggests an increase in precipitation for all seasons except the pre-monsoon.

Table 5-4: Projected range of Multi-model ensemble mean change in precipitation (%)for different sessions

Seasons	Medium-term (2016-2045)		Long-term (2036-2065)		End of the Century 2071 – 2100	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Winter	-5.8	7.2	13.6	5.0	24.4	20.9
Pre-monsoon	-5.0	-4.0	-7.4	4.2	-7.8	-3.1
Monsoon	2.7	7.8	9.4	13.6	12.4	27.1
Post-monsoon	18.6	6.0	20.3	19.0	16.5	22.9
Annual	2.1	6.4	7.9	12.1	10.7	23.0

Source: MoFE (2018)

Table 5-5 shows a mean change in annual and seasonal precipitation for different physiographic zones. The changes in precipitation are higher in High Mountains than other physiographic

regions for most of the periods. The High Mountains is likely to warm at a higher rate than the rest of the regions, except Terai and Siwaliks in RCP8.5 scenario.

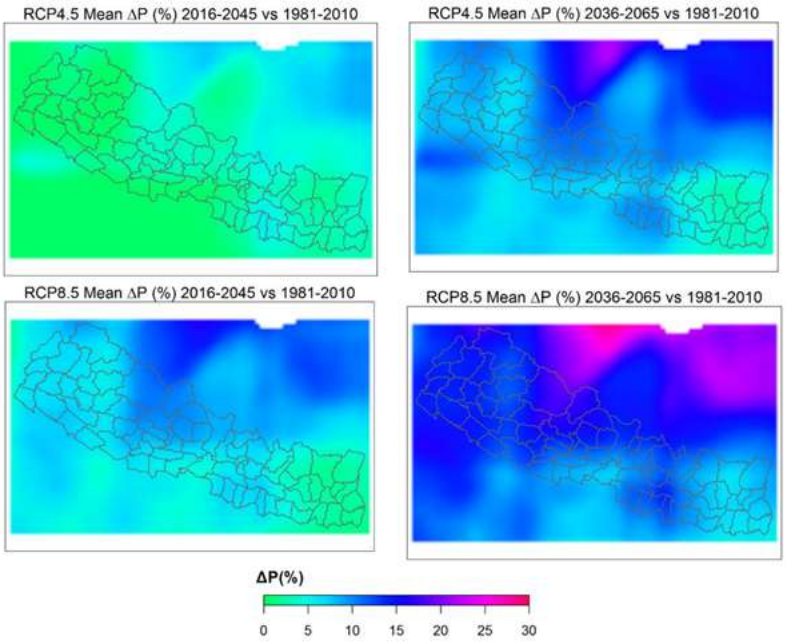
Table 5-5: Projected range of multi-model ensemble mean change in precipitation (%) for different regions of Nepal in three time periods with respect to reference period

physiographic regions	Medium-term (2016-2045)		Long-term (2036-2065)		End of the Century 2071 – 2100	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
High Mountain	2.6	8.0	9.5	14.4	12.6	25.1
Middle Mountain	1.7	6.3	7.6	12.4	10.3	21.7
Hill	2.1	5.8	7.2	11.2	9.9	22.6
Siwalik	1.6	5.8	7.4	11.1	9.9	21.9
Terai	2.1	5.4	7.3	10.6	10.2	22.7

Source: MoFE (2018)

Spatial pattern of projected changes in mean annual precipitation is shown in Figure 5-5 for medium-term and long-term periods. Snowfall is projected to decrease considerably because of temperature increase leading to reduction of snow storage, ultimately resulting in a distinct decrease in snowmelt runoff from non-glaciated areas (Nepal, 2016).

Figure 5-5: Multi-model mean change in annual precipitation vis-a-vis reference period (1981-2010)



Source: MoFE (2018)

c. Projection of extreme indices

Table 5-6 shows mean change in extreme temperature indices (days) in medium-term and long-term with respect to reference period. Compared to reference period, warm extreme events (warm days, warm nights and warm spell duration) are projected to increase while cold extreme indices (cloudy days, cold nights and cold spell duration) are projected to decrease for both medium-term and long-term periods. The rate of increase in warm nights is highest in both periods: (30.5-37.8 days) in the medium term and (43.3-59.6 days) in the long-term.

Table 5-6: Projected range of multi-model ensemble mean change in extreme temperature indices

Indices	Mean annual days in the reference period (1981-2010)	Medium-term (2016-2045)		Long-term (2036-2065)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
	(Days)	(Days)	(Days)	(Days)	(Days)
Warm days	36.5	23.9	26.4	32.3	46.1
Warm nights	36.5	30.5	37.8	43.3	59.6
Warm spell Duration	17.6	19.3	27.6	26.2	43
Cold days	36.5	-15.4	-20.5	-19.3	-27.5
Cold nights	36.5	-15	-19.9	-19.7	-27.3
Cold Spell Duration	20.3	-10.5	-11.2	-12.9	-14.8

Source: MoFE (2018)

Compared to reference period, very wet and extremely wet days are expected to increase in future (Table 5-7). Rainy days are expected to decrease. This decrease is higher in RCP4.5 than in RCP8.5. Dry Spell and wet spells changes seem to be opposite in two RCP scenarios.

Table 5-7: Projected range of multi-model mean changes in extreme precipitation indices (days) with respect to reference period

Indices	Mean annual days in reference period (1981-2010)	Medium-term (2016-2045)		Long-term (2036-2065)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
	(Days)	(Days)	(Days)	(Days)	(Days)
Very Wet Days	18.1	0.3	2.2	2.2	3.4
Extremely Wet Days	3.5	0.9	1.0	1.4	2.1
Rainy days	166.4	-3	-1.6	-1.7	-0.8
CDD	45.3	2.7	-0.7	1.1	-1.3
CWD	78.1	-3.3	2.5	-1	1.7

Source: MoFE (2018)

The following sub-sections will include the assessment of vulnerability in key sectors, and discuss adaptation measures.

5.4. Agriculture and Food Security

5.4.1. Overview of Agriculture and Food Security Sector

Agriculture

Agriculture is the backbone of socio-economic development in rural Nepal. This sector employs more than 66% population (>70% of women population) and contributes to 27.6% of GDP (CBS, 2014; MoF, 2018). The total agricultural land is 4,243,160 ha (29.7% of total area) with per capita availability of 0.082 ha and households owning less than 0.5 ha 51% (MoAD, 2014). Nepal's physiographic regions are the key determinants of farming systems and crop patterns owing to their different elevation, climate, catchment features, and agro-ecological zones. Paddy, maize, wheat, millet, buckwheat and barley are the major cereal crops. Among the commonly cultivated crops, rice, buckwheat, soybean, foxtail millet, and mango have higher genetic diversity than other crops (MoAD, 2017).

Similarly, livestock is also an integral part of the Nepalese farming system with cattle, goat, sheep and buffalo as major reared animals (Table 5-8). Livestock contributes over 10% of the GDP and over a quarter of the agricultural GDP (MoLD, 2017). It also accounts for 14% of total protein requirement (Farquher et al., 2018) and constitutes the highest portion of household income (Neupane et al., 2018).

Fisheries contributes over 1.32% of GDP (MoAD, 2017). The demand for fish is expected to increase from 46,000 to 364,000 metric tons between 2008 and 2032 (94% from aquaculture and 6% from capture fisheries) (MoAD, 2017).

Table 5-8: Livestock population by category or type of livestock in Nepal, 2017

Type of livestock	Number of holding	Number of heads	Per capita holding
Cattle	2,280,542	6,430,397	2.82
Buffalo	1,668,820	3,174,389	1.90
Sheep	98,464	612,884	6.22
Goat	2,463,253	11,225,130	4.56
Pig	477,984	870,197	1.82
Yak/Nak/Chauri	6,235	48,865	7.84
TOTAL	**6,995,298**	**22,361,862**	**3.20**

Source: MoAD (2017)

However, investment in agriculture is not encouraging (Adhikari, 2015). Consequently, poverty, food insecurity and malnutrition continue to plague the farming communities. Almost 50% households in the country are food insecure, nearly one-fourth are poor, and 14% are undernourished (MoALMC, 2018). The country also faces a huge agriculture trade deficit. Further, lack of access to women, poor and marginal communities on productive resources (especially land) have pushed them to food insecurity (FAO, 2004).

Food Security

Large fraction of Nepalese people particularly poor and vulnerable suffer from under nutrition. Nepal shows gains on nutrition indicators like stunting, wasting, underweight, low body mass index, micronutrient deficiency, overweight and obesity (Table 5-9). However, malnutrition continues to affect the poor. Malnutrition contributes to more than a third of child mortality; those who survive often lead diminished lives due to impaired cognitive development, reduced economic productivity and the increased risk of malnutrition-related chronic diseases (NPC, 2017). At the same, time the problem of overweight and obesity is increasing among urban population.

Table 5-9: Nepal's status on SDG nutritional targets

	SDG targets for 2030	Base year situation (2011)	Progress (2016)	Nepal's SDG targets (2030)
1	Achieve 40% reduction in the number of children unde-5 who are stunted	40.5%	35.8%	15%
2a	Achieve 50% reduction of anaemia in women of reproductive age	35.0%	40.8%	10%
2b	Achieve 50% reduction of anaemia in children	46.2%	52.7%	10%
3	Achieve 30% reduction in low birth weight	12.1%	24.2%	-

4	Ensure no increase in childhood overweight	1.4%	1.2%	-
5	Increase rate of exclusive breast feeding in first 6 months to at least 50%	69.6%	66.1%	-
6	Reduce and maintain childhood wasting to less than 5%	10.9%	9.7%	4%

Source: NPC (2017)

Agricultural Development Strategy (2015) proposed self-sufficiency in food grains by 2020 and five percent surplus by 2025. The plan is also to reduce food poverty from 24% in 2010 to 5% by 2035. Policies such as the Zero Hunger Challenge (ZHC), ADS, Food and Nutrition Security Plan of Action (FNSPA), and MSNP have proposed several coordination committees and horizontal coordination structures at federal, regional, district, and local levels. ZH National Action Plan (2025) covers ways of creating ability of vulnerable groups in obtaining access to food and nutrition security as their basic rights.

5.4.2. Vulnerability and Impact of Climate Change

Impacts

Agriculture is significantly affected by increasing temperatures and extreme rainfall variabilities (Box 5-1). Temperature rise will increase evapotranspiration, leading to greater demand for irrigation water, and reduction in river flows. Glacier-fed perennial rivers will be converted into rain-fed seasonal rivers after the glaciers disappear. The ratio of maximum to minimum flows of rain-fed rivers is higher than that of snow-fed rivers. This will redistribute water flow across seasons and months. It will eventually widen the gap between the water supply and demand.

About 70% of crop production is determined by climatic variability, and rain deficit, drought and floods cause significant (between 10 and 30%) decline in production (IDS-Nepal, PAC and GCAP, 2014). Between 1971 and 2007, nearly 850,000 ha of planted crops were lost to weather and climate-related events. Of all hydro-meteorological hazards, droughts have had the most severe impact on crops which, for instance, alone account for 38.9% of the loss of agricultural crops, while floods account for 23.2% (UNDP, 2009). In 2006 alone drought caused the loss of 11% in rice yield and 7% in wheat (MoHA & DPNet-Nepal, 2015). On the contrary, with the increase in temperature and precipitation, higher altitude areas experienced early ripening of crops and increase in yield, (Malla, 2008).

Box 5-1. Impact of Climate Change on Agriculture

- Climate change is leading towards increased food insecurity in Nepal. Over 10% of decline in production is attributed to climate induced disasters and lack of adaptation action.
- Due to drought in 2006, yield reduced by 11% in rice and 7% in wheat. The drought in the eastern region decreased rice production by 30%, and heavy flooding in the mid-western and far-western regions in 2006 and 2008 destroyed crops in many places (Practical Action, 2008).
- More than 150 drought events during 1971 to 2007 affected about 330 thousand hectares of agriculture land (UNDP, 2009).
- Due to extreme weather conditions, the rice yield in the Terai is projected to decrease by 10% by 2070s (MoSTE, 2014).
- Around 1.6% decline in rice production and 15.5% decrease in wheat yield are projected by 2020.
- Food grain production will decrease by 5.3% in 2020 (NAP, 2016).

Source: NAP (2016)

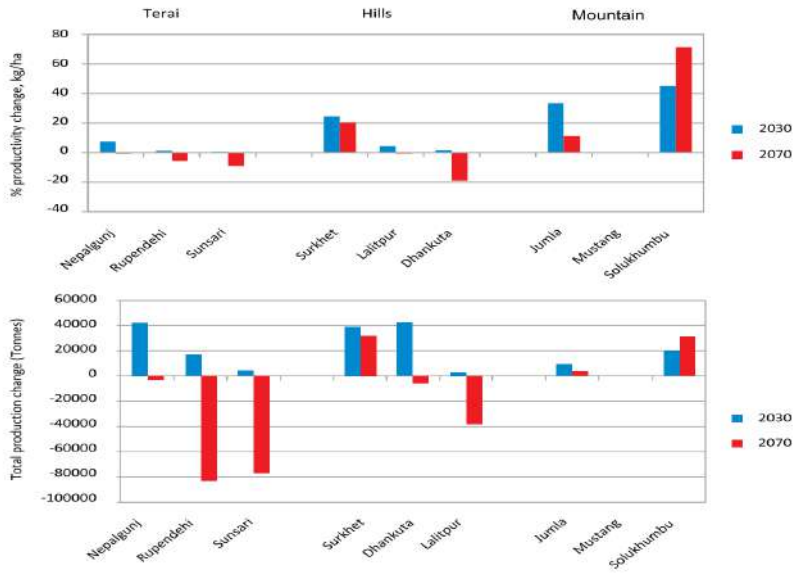
Livestock are affected by rising temperatures as their reproduction, breeding, or digestion are exacerbated by heat- and drought-related deaths and diseases (Wagle et al., 2011). Movement of herds and migratory species are also affected (Pokharel& Pandey, 2011). Likewise, the rise in temperature causes loss of fish; deterioration of water quality brings diseases and causes mass morbidity. MoPE (2017b) estimates a 2–4% drop in current GDP per year due to climate change, with the need for USD 2.4 billion in adaptation by 2030. In the agriculture sector, losses in paddy due to droughts amounted to USD 753 million from 2001 to 2010, with USD 75 million being lost on average annually (UNDP, 2013).

Temperature rise can have significant adverse impacts on agriculture production and food security. Water supply is the single most important factor in food production (McGuigan et al., 2002). Changes in glacier melt, along with other changes in high-altitude hydrology, will affect agricultural production (Malone, 2010). Subsistence farmers and the poor will face the biggest adverse impact due to reduced water availability, which may lead to the famine (Chaulagain, 2015).

MoSTE (2014) and Devkota et al. (2017) evaluated the effects of climate change on productivity of three major crops (rice, wheat and maize) in nine sample districts in five physiographic zones. There is a complex mix of increase or decrease in rice yield which varies over time (2030s and 2070s) and by location (east to west/Terai to mountains). In Terai, the yield increases over short term (2030), but may decrease up to 10% over the Chau again long-term (2070s) (Figure 5-6). This is due to a combination of lower rainfall and higher temperature during the growing season.

In the hill region, there is generally a more positive trend with rice productivity increase in the short-term (2030s). In the longer-term (2070s), while a positive trend will continue in the west, there will be a decline in productivity growth for the east (almost 20%). In the mountain region, yield will increase in the short and the long-term, due to rising temperatures during the growing season.

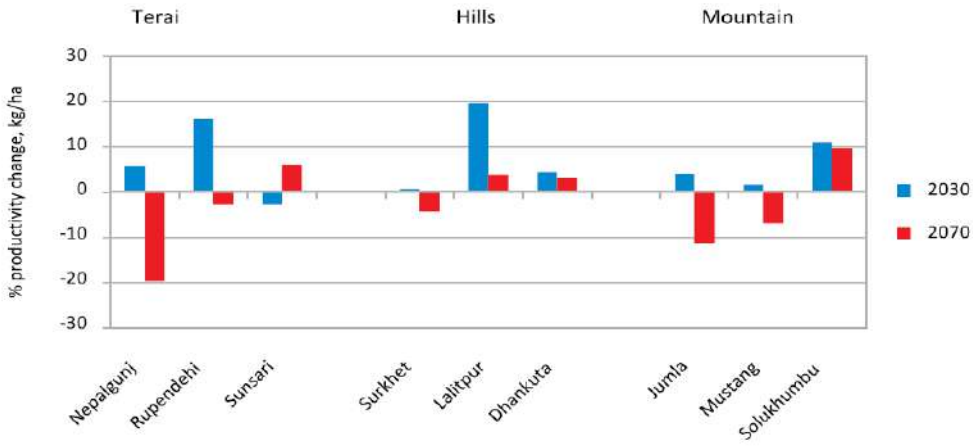
Figure 5-6: Change in rice productivity and total production due to climate change, relative to baseline



Source: MoSTE (2014a)

The impact of climate change on maize is more differentiated than for rice (Figure 5-7). In the Terai, maize yield will increase over the short term in the west and central areas, but not the east. But it will be followed by a sharply decrease (20%) in the west in the long-term (2070s). In the hills, the yield will increase over both short and long-term (2070s) in the east and central regions, but a small decline in the west in the long-term. In the Mountains, the yield will increase in all areas (especially in the east) in short term. In the long-term (2070s) the yield will decline in western and central areas.

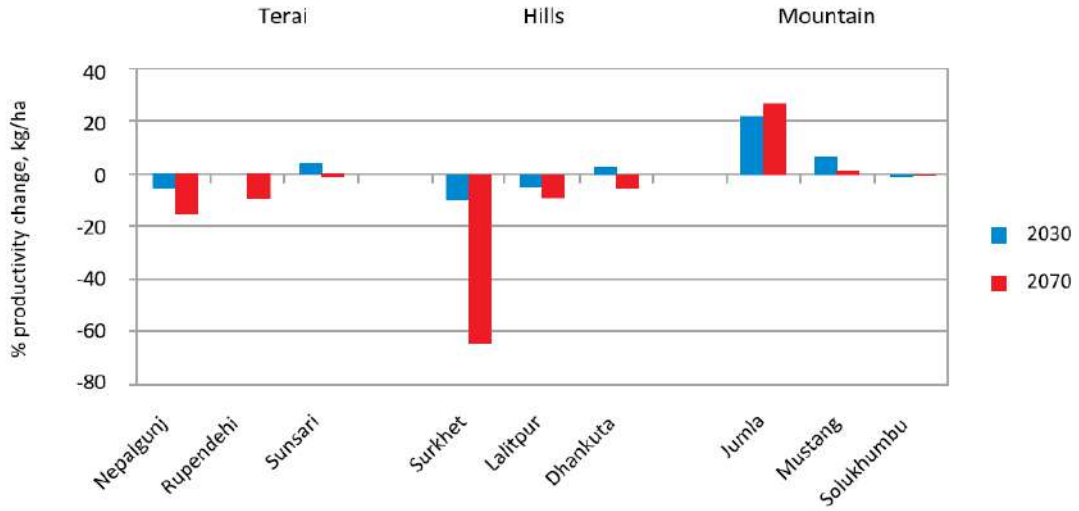
Figure 5-7: Change in maize yield from climate change, relative to baseline period



Source: MoSTE (2014a)

The impacts of climate change on wheat shows an initial increase in yield in the short term, but large decline in central and western Terai in the long-term (Figure 5-18). For the hills, there will be more mixed impact in the 2030s, but decrease in yields across all areas in the 2070s. There will particularly be high decline in the western hills whereas only modest changes will occur in eastern areas.

Figure 5-8: Change in wheat yields from climate change, relative to baseline period.



Source: MoSTE **(2014a)**

Vulnerability

Main climatic hazards affecting agriculture include flood, drought, windstorm, hailstorm, cold wave, heat wave, and various kinds of extreme events. The proportion of population exposed to climatic hazards is very high. Floods, droughts and erratic rainfall are recurrent problems facing agriculture, livestock and fisheries (Sherchand et al., 2007). Since more than 50% of farming is dependent on natural rainfall, it is highly sensitive to drought (Adhikari, 2018).

Nepalese agriculture is represented by small holding farmers; half of them depends on natural rainfall. Of the total cultivated area, some 69.92% is irrigated while 30.08% area is rain-fed (MoAD, 2017). Much of the irrigation comes from surface flows (Table 5-10). However, during the winter (dry) season, surface flow is reduced drastically and groundwater becomes the main source of irrigation. As a result, intensive irrigation in Nepal differs in summer and spring seasons.

Table 5-10: Status of irrigation in Nepal

SN	Land area by mode of irrigation	Values (%)
1	Surface irrigation	55.67
2	Ground water irrigation	29.38
3	New-technology based irrigation	0.42
4	Improved farmers irrigation canal	14.53

Source: MoF (2017)

The major hazards and climate extreme events that impact agriculture and food security are extreme hot and cold days, consecutive wet and dry days, extreme weather variability, and climate-induced hazards such as floods, landslides, crop inundation, drought, and hailstorms. These have negative impacts on crop and livestock productivity and food supply systems, which in affect the livelihoods of the poor and vulnerable households. The increases in temperature and extreme events are potential hazards for agriculture.

The effects of higher temperatures, and changes in rainfall and rainfall variability on agriculture productivity can be both positive (such as CO_2 fertilization and extended growing seasons in colder regions) and negative (e.g., low rainfall). However, there may also be changes in the length or timing of seasons and increasing intensity or frequency of extremes (floods and droughts), changes in pests and diseases (range and prevalence/incidence), factors affecting soil conditions or soil erosion, and from other impacts on the value chain (e.g., on rural roads). These pose risks and uncertainty to livelihoods.

Sensitivity of agriculture to climate hazards, variation and extremes depends on crop phenology, availability of irrigation, plant varieties, livestock breeds, cropping pattern, fodder and forage availability and landholding size. For example, crop phenological cycle determines level of impacts of hazards and extreme events on the sowing period, early growth period, flowering period and harvesting period. Similarly, mono cropping practice is more sensitive to climate induced hazards and pest and insects because of the risk of loss and damage of the crops, more exposure for weeds production henceforth decreasing the yield of the crops. Fodder requires different climatic conditions and it has immense variation in growth as well as productivity of quality green fodder. The quality of green fodder changes with the variation with climate, which also impact the quality of animal products; hence, the availability of fodder and forage in dry and wet season determines sensitivity of livestock to climate change. Nepal has

very limited practice of growing fodder for livestock, but depends mainly on grazing. Degradation of grazing land due to climate change has made livestock sector more sensitive to climate change.

5.4.3. Adaptation Measures to Reduce Vulnerability

NAPA has recommended several adaptation programmes for reducing vulnerability to the climate change (MoE, 2010). It emphasizes awareness raising, capacity building, and technology transfer. Several technologies useful for climate change adaptation and vulnerability reduction are already available, but the adoption of these technologies is very limited.

NARC is engaged in breeding drought-tolerant varieties of the crops such as Hardinath-1, Radha-4, Barkhe varieties of rice, Gautam and WK 1204 varieties of wheat and Manakamana, Rampur Composite, and Deuti varieties of maize. Additionally, NARC has released rice variety for submerged condition (IR 64). There is immense scope for climate change adaptation through developing drought tolerant varieties, submerged varieties, early maturing and pest resistance varieties, and varieties suitable for high temperatures. In addition, many farmers and some NGOs are also involved in developing crop varieties suitable for changed climatic conditions.

The GoN has initiated a number of efforts to reduce vulnerability of climate change. These include: System of Rice Intensification (SRI); green manuring; conservation tillage practices; use of plastic house and water sprinklers; sustainable agriculture soil and water conservation; slope stabilization and landslide control; rainwater harvesting, rangeland and forage improvement; cultivation on river beds and shrub land; livestock shed improvement; bioenergy; and adoption of biogas. These efforts need further development along with other new initiatives.

5.5. Water Resources and Energy

5.5.1. Overview of Water Resources and Energy Sector

Water Resources

Nepal has immense water potential of 226 billion cubic meters (BCM) per annum; however, very small proportion (around 15 BCM) has been utilized for socio-economic purposes (WECS, 2011). Out of the total water used, agriculture consumes 96% of water use, domestic sector 3.8% and industry 0.3% (ADB/ICIMOD, 2006). Except for a few run-of-the river hydropower projects, most of rivers have been untapped (WECS, 2011).

The country's energy sector is dominated by biomass as a primary source, comprising 80% of total energy supply (ADB, 2017). For electricity supply, hydropower is the principal source. Thus, vulnerability of hydropower sector to climate change is likely to represents overall vulnerability of energy sector in Nepal.

River System

Nepal's rivers exhibit a wide seasonal fluctuation of flows, with the monthly flows generally reaching their maximum in July-August and minimum in February-March. The smaller rivers have wider flow fluctuations than the larger ones. The total available runoff is 7,124 m^3s^{-1}(Table 5-11).

About 78% of the average flow in Nepal is available in four major river basins, 9% in the medium basins and 13% in the smaller southern rivers of the Terai. The southern slopes of the Mahabharat range, the Himalayan range and the eastern two-third of Nepal receive the highest amount of precipitation and there is relatively high contribution of flows of the rivers within the

catchments of these areas. About 74% of the total annual surface flow occurs in four months from June to September (WECS, 2011).

Table 5-11:Runoff and Drainage Area of Major River Systems of Nepal

SN	Name of river	Length (km)	Drainage Area (km^2)		Runoff ($m^3 s^{-1}$)	
			Total	Nepal	From all basin	From Nepal
1	Mahakali	223	15,260	5,410	698	247
2	Karnali	507	44,000	41,890	1441	1371
3	Babai	190	3,400	3,400	103	103
4	West Rapti	257	6,500	6,500	224	224
5	Narayani	332	34,960	28,090	1753	1409
6	Bagmati	163	3,700	3,700	178	178
7	Saptakoshi	513	60,400	31,940	1658	878
8	Kankai	108	1330	1330	68	68
9	Others	-	24,921	24,921	1001	1001
Total			**194,471**	**141,181**	**7124**	**5479**

Source: WECS (2002) cited from WECS (2011) & CBS (2013)

Lakes

Nepal has 5,358 lakes; 2712 (50.62%) lie below 500 m, 2227 lie above 3000 m and only 419 (<8%) lie between 500 m and 2999 m (Bhuju et al., 2010; NLCDC, 2009). An inventory (1996) recorded 163 wetlands in Terai, and 79 in the Hills and Mountains. There are 10 Ramsar sites spread over Mountains, Mid-hills and Terai (Table 5-12).

Table 5-12: Lakes recognized as Ramsar sites in Nepal

SN	Name of Ramsar Site	Location	Inclusion Date	Area (ha.)	Elevation (m)
1	Koshi Tappu	Koshi	17 December1987	17500	75-81
2	Beeshazari and Associated Lake	Chitwan	13 August 2003	3200	286
3	Ghodaghodi Lake Area	Kailali	13 August 2003	2563	205
4	Jagadishpur Reservoir	Kapilvastu	13 August 2003	225	197
5	Gokyo and Associated Lakes	Solukhumbu	23 September 2007	7770	4700-5000
6	Gosaikund and Associated Lakes	Rasuwa	23 September 2007	1030	4000-4700
7	Phoksundo Lake	Dolpa	23 September 2007	494	3611.5
8	Rara Lake	Mugu	23 September 2007	1583	2990
9	Mai Pokhari	Ilam	28 October 2008	90	2100
10	Pokhara Valley Lake Cluster*	Kaski	02 February, 2016	924	-

Source: DNPWC, 2019

Glaciers and Glacial Lakes

About 23% of the total area lies above the permanent snowline of 5,000 m (MoPE, 2004; WECS, 2011). About 3.6% of the total area of the country is covered by glaciers (Mool et al., 2001), whereas about 10% of the total precipitation falls as snow (UNEP, 2001). The first glacial inventory reported a total of 3,252 glaciers with a combined area of 5,324 km^2 and an ice reserve of 481.32 km^3 (Mool et al., 2001) (Table 5-13). A further study in 2009 has revealed 1,466 glacial lakes with an area of 64.78 km^2 (Ives et al., 2010; ICIMOD, 2011a; Table 5-13). One of the most recent glacier inventories used Landsat satellite images of 2010 and reported 3,808 glaciers with an area of 3,902 km^2 with total ice reserve 312 km^3. The total number of glaciers

was reported to be the highest in the Karnali and Gandaki basins, whereas the area and ice reserves were highest in Gandaki and Koshi basins (Bajracharya et al., 2014).

Table 5-13: Distribution of glaciers in the major river basins of Nepal

	2001 inventory*				2010 inventory**				
Basin	**Number**	**Total area (km^2)**	**Mean area (km^2)**	**Ice reserve (km^3)**	**Number**	**Total area (km^2)**	**Ice reserve (km^3)**	**Highest elevation (masl)**	**Lowest elevation (masl)**
Koshi	779	1,410	1.81	152.06	843	1,102.6	110.64	8,437	3,962
Gandaki	1,025	2,030	1.98	191.39	1,337	1,664.5	134.75	8,093	3,273
Karnali	1,361	1,740	1.28	127.8	1,461	1,022.8	60.04	7,515	3,631
Mahakali	87	143.34	1.65	10.06	167	112.5	6.97	6,850	3,695
Total	**3,252**	**5,324**	**1.64**	**481.31**	**3,808**	**3,902.4**	**312.40**	- -	- -

Source: *Mool et al. (2001); **Bajracharya et al. (2014)

The average area of individual glaciers was reported to be less than 1 km^2 in the Mahakali and Karnali basins, greater than 1 km^2 in the Gandaki and Koshi basins, and just over 1 km^2 in overall.

Ground Water

Nepal's Terai has one of the most productive aquifers in the South Asia (UNEP, 2001). It has a groundwater recharge potential of about 6.5 billion cubic meter and about 3.1 billion cubic meters in Chure/Bhavar making a total of 9.6 billion cubic m (JVS/GWP Nepal, 2014). The volume of water available for groundwater extraction is between 5.8 yr^{-1} and 12 billion m^3 yr^{-1}. For Kathmandu Valley, the estimates vary from 4.6 million m^3 yr^{-1} to 14.6 million m^3 yr^{-1} (Pandey et al., 2014). However, groundwater extraction in the Valley is already many times higher than its recharge rate (Shrestha et al., 2012).

Groundwater extraction in Nepal is estimated to be 1.935 BCM/year, of which nearly 1.8 BCM/year is used for agriculture and 0.46 BCM/year is for domestic use (Shrestha et al., 2018). Around 1,300 Deep Tube-wells (DTW) and 50,000 Shallow Tube-wells (STW) - excluding hand, rower and treadle pumps - have been installed in the country (WECS, 2011). The rate of decline in groundwater recharge because of climate change has not been estimated; but different rates of change for different climate change scenarios are shown (Brouyere et al., 2004; Chen & Chen, 2004).

Use of Water Resources

Agriculture is the largest water use sector. Nepal has a cultivated area of 2,642,000 ha (18% of its land area); its two-third (or 1,766,000 ha) is potentially irrigable. However, only 42% of the cultivated area has irrigation facilities and 17% has year-round irrigation (Table 5-14). In Terai, 82% of the irrigated area (889,000 ha) has surface irrigation and the remaining 18% through groundwater (WECS, 2011). Irrigation schemes contribute 65% of the country's agriculture production (WECS, 2005) as compared to 40% crop output from 18% irrigated land in the world (Schultz, 2002).

Water use for hydro-energy is another key sector, contributing to 1.09% of GDP. It further supports the economy by powering electricity dependent sectors such as industry, construction, service and agriculture (MoPE, 2017a). The hydropower potential of Nepal was estimated to be 83,000 MW in 1966, out of which only 42,000 MW was identified as technically and economically feasible (Shrestha, 1966). The recent estimate at 40% dependable flows and 80%

efficiency for the ROR hydropower potential in Nepal stands at 53,836 MW (Jha, 2010). By 2019, total installed hydropower capacity has reached to just 1180MW. At the same time, the GoN has initiated construction of storage hydropower projects such as Dudhkoshi (762 MW), Uttar Ganga (828 MW) and Andhikhola (180 MW) (NEA, 2017).

Table 5-14: Irrigation potential and development in Nepal

Geographic Region	Total Area (10^3 ha)				Irrigated as % of cultivated	Year round irrigated as % of irrigated
	Cultivated	Irrigable	Irrigated	Year-round irrigation		
Terai	1,360	1,338	889	368	65	41
Hills	1,054	369	167	66	16	39
Mountains	227	60	48	18	21	38
Total	2,642	1,766	1,104	452	42	41

Source: WECS (2005, 2011)

The domestic water demand, including for sanitation, is the other water use sector in Nepal. National water supply facility coverage has reached 83.59% against the MDG target of 73% by 2015. In the same period, national sanitation coverage reached 70.28% (NMIP, 2014). By ecological region, water supply facility reached 80.19% in Mountain, 84.89% in Hills and 84.78% in Terai. The sanitation coverage in 2014 reached 74.48% in mountain, 87.14% in hill and 56.93% in Terai (NMIP, 2014).

Energy Sector

Total electricity supply in 2018 was 7,057 Gigawatt-hours (GWh), nearly 63% of that was generated from hydropower (Nepal Electricity Authority, 2018). Installed power generation capacity has grown from 706 MW in FY2011 to 856 MW in FY2016. Interestingly, peak demand for the same period has increased even faster, from 946 MW to 1,385 MW (Table 5-15).

Table 5-15: Electricity demand, supply and deficit for the period of 2011-2016.

Item			**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**Annual Growth Rate (%)**
Installed capacity (MW)*			706	7,19	762	787	787	856	3.9
Peak demand (MW)			946	1,027	1,095	1,201	1,292	1,385	7.9
Supply capacity shortage (MW)			240	308	333	414	505	529	17.1
Electricity requirement (GWh)			4,833	5,195	5,446	5,910	6,335	6,920	7.4
Supply (GWh)	NEA	Hydro	2,122	2,357	2,273	2,288	2,366	2,168	0.4
		Thermal	3	2	19	10	1	0.1	0
		Total NEA	2,125	2,359	2,292	2,298	2,367	2,169	0.3
	IPPs		1,039	1,074	1,176	1,070	1,269	1,173	2.5
	Imports		694	746	790	1,319	1,370	1,758	20.4
	Total		3,858	4,179	4,258	4687	5,006	5,100	5.7
Supply shortage (GWh)			975	1016	1,188	1,223	1,329	1,820	13.3

Source: ADB (2017b)

Notes: * includes power generation capacity of both NEA and IPPs. Acronym: GWh is Gigawatt-hour; IPP is Independent Power Producer; MW is Megawatt; NEA is Nepal Electricity Authority.

Total energy supply has increased from 5,789 kilotonnes (kton) in 1990 to 11,690 kton in 2014 (Table 5-16). Main sources of primary energy in Nepal are biomass, oil products, coal, and hydropower. There is dominance of biomass in the form of firewood, agricultural waste, and animal dung, as the source of energy supply. The biomass contributes 80% of the energy supply mix, followed by oil products (12%), coal (4%), and hydro-electricity (4%). In terms of consumption, residential sector is the major consumer (84%) followed by transport (7%), industry (6%), commercial and public (2%), and agriculture (1%).

Table 5-16: Energy supply and consumption trend (1990-2014) in kilotons of oil equivalent (kton)

Item	1990	1995	2000	2005	2010	2014
Total Primary Energy Supply	**5,789**	**6,712**	**8,108**	**9,132**	**10,211**	**11,690**
Coal	49	74	258	248	303	484
Oil Products	244	501	713	724	983	1,359
Natural gas	0	0	0	0	0	0
Hydro	75	100	140	216	276	326
Biomass	5,425	6,039	6,988	7,928	8,592	9,403
Total Final Energy Consumption	**5,761**	**6,667**	**8,041**	**9,050**	**10,107**	**11,534**
Industry	106	161	379	388	449	665
Transport	111	203	270	275	637	858
Residential	5,465	6,170	7,199	8,128	8,718	9,624
Commercial and public services	43	60	97	165	171	219
Agriculture/Forestry	33	60	75	72	118	151
Non-energy use	4	7	11	20	10	8

Source: ADB (2017b)

5.5.2. Vulnerability and Impacts Assessment

Impacts

Impacts of water resources and energy sector to climate change can be discussed principally in following aspects (Schaeffer et al., 2012): i) resources endowment; ii) energy supply; iii) transmission, distribution, and transfer; and iv) energy use.

a) Impacts on resource endowment

Water availability, its spatio-temporal distribution, and hydrological cycle are altered by climate change/variability. The variations in climate phenomena have resulted in accelerated melting of glaciers, formation of glacial lakes in the mountain valleys and expansion of existing glacial lakes (Gardelle et al., 2011; Salerno et al., 2012). This retreat of glaciers and associated change in hydrology affects availability of water resources and subsequent impacts on energy generation. For instance, the comparison of imageries and field-observation has shown formation of supra-glacial lakes in the Ngozompa and Imja Glaciers (Benn et al., 2012; Thakuri et al., 2016). Between 1975 and 2000, the area occupied by major lakes has also increased by 8.3% (WECS, 2011). The contribution of snow and glacier melt to total discharge during the period of 1985 to 1997 was about 34% annually, whereas it was 63% in the pre-monsoon season (March to May). Future projections indicate a 13% increase in annual discharge by mid-century followed by a slight decrease; and a 16% increase in evapotranspiration by the end of the century. The increase in annual discharge will result mostly during the monsoon season, leading to more frequent flood events (Nepal, 2016). The projected rate of change is not consistent across the country. For example, the figure is +15% by the end of century in Chamelia, a tributary of

Mahakali River (Pandey et al., 2019a), and up to 50% in some sub-watersheds of Karnali River basin (Pandey et al., 2019b). The contribution of snowmelt is projected to increase by 90% by 2090 (Bajracharya et al., 2018).

The current trend analysis of discharge in Central Nepal revealed an increase in annual average, maximum, and minimum flows. This increase in streamflow coincides with the increasing rainfall trend of the yearly monsoon (June–September) and pre-monsoon (March–May) periods (Gautam et al., 2010). Glacial melt is expected to increase up to mid-century and start decreasing thereafter, which have impacts on resources endowments.

A study from the Everest region, specifically Imja Tsho Lake and Imja Glacier resulted that the lake had expanded from 0.03 to 1.35 km^2 between 1962 and 2013. In the lower part of glacier, it was noted that the mean glacier elevation had changed from -1.29 m yr^{-1} during 2001 to 2008 and 1.56 m yr^{-1} during 2008 to 2014 (Thakuri et al., 2016). Here, the changes in glacier dynamics, e.g., glacier thinning and expansion of glacial lakes, could be the consequences of change in precipitation and temperature (Thakuri et al., 2016). Ojha et al. (2016) showed that in the Eastern Nepal, clean glaciers (i.e., not covered by debris) have lost 11.2% of its surface area since 1992. Further, the number of glaciers has increased by 5% and sixty-one small glaciers with 2.4 km^2 are disappeared (Ojha et al., 2016).

ICIMOD (2011a) has identified 21 glacial lakes to be potentially dangerous. These glacial lakes are classified into 3 categories. Among the 21 glacial lakes, six are classified as Category-1, four as Category-2, and 11 as Category-3. The Category-1 lakes include; Tsho Rolpa, Lower Barun, Imja Tsho, and Lumding, and Category-2 lakes include; Nagma, Hungu (2), and Tam Pokhari. Substantial areas of different land-use and land-cover have been reported to be exposed to potential Glacial Lake Outburst Floods (GLOFs) risk of major three glacial lakes- Tsho Ropla, Thulagi Lake, and Imja Tsho (Table 5-17).

Table 5-17: Land-cover types exposed to GLOF risks from the three lakes up to 100 km downstream

Land-cover type	Tsho Rolpa		Thulagi Lake		Imja Tsho	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Agriculture land	169.8	20.4	188.7	16.7	87.6	8.7
Forest	68.6	8.2	73.9	6.5	206.9	20.5
Shrubland	37.4	4.5	-	-	24.1	2.4
Grass	4.2	0.5	33.3	2.9	54.1	5.4
Barren land	38.1	4.6	15.6	1.4	35.8	3.5
River course	515.0	61.8	821.3	72.5	567.0	56.1
Other	-	-	-	-	34.4	3.4
Total	833.2	100	1132.8	100	1009.9	100

(ICIMOD, 2011a)

b) Impacts on energy supply

The amount of energy from a hydropower plant depends not only on the installed generation capacity, but also on the variation in water inflows to the power plants, rate of temperature increase, and location of hydropower plant, among others. Changing climatic conditions may affect the operational plan of existing hydropower system, which are based on historical records of climate patterns, and therefore, impacts on energy supply. Initially, the electricity generation potential may increase with the rise in temperature, and then could gradually decline

(NDRI/PAC/GCAP, 2017). However, the electricity generation (or energy supply) may also depend on the rainfall contribution, which is adversely affected due to changed precipitation pattern (i.e., too much of rainfall during monsoon and too little during non-monsoon seasons). Because of the insufficient river flows during dry season, the existing hydropower plants could generate just around 30% of the total installed capacity of the hydropower plants (NEA, 2013). Decrease in glacier ice reserve causes decreased river-flow, further deteriorating the electricity generation. Other factors that relate to energy supply to a consumer is the geographical dispersion and the level of integration through transmission capacity. Highly interconnected transmission lines may play an important role in coping with regional climate variability by supplying adequate energy. Furthermore, characteristics of individual plants also influence the vulnerability of hydropower systems to climate change. Small ROR plants offer little operational flexibility and are more vulnerable to climatic variations compared to reservoir or storage plants.

c) Impacts on transmission, distribution, and transfer

Transmission and transfer of energy extend to thousands of kilometres and can be exposed to extreme weather and climate events. For example, extreme winds, ice loads, combined wind-on-ice loads, avalanches, landslides, or flooding are the climate/weather phenomena that may impact on transmission, distribution, and transfer of energy. However, there is no data/information on these types of impacts of climate change in Nepal.

d) Impacts on energy use

Temperature and rainfall variations can impact on energy use. For example, higher temperature may imply lower demand for heating and higher demand for cooling. In addition, performance of motors and engines can vary with temperature. Similarly, climate change may also affect the water (and electricity) demand in industries and in agriculture.

Vulnerability

Nepal's annual renewable water availability is 7,173 m^3 $capita^{-1}$ yr^{-1} (2014 value) (FAO-AQUASTAT, 2019), which is well above the global average and the water stress level of 1700 m^3 $capita^{-1}$ yr^{-1}. However, a large section of population and irrigation lands are still waiting for adequate access to water. Future temperature change scenarios and the United Nations population projection for 2100 AD have revealed that the annual renewable water availability in Nepal will be above the critical line of water stress (Chaulagain, 2015). However, water stress is already a common during the non-monsoon seasons. Furthermore, pollution of river system, mainly in cities, due to disposal of untreated sewage is threatening ecological security. Yet, successful cases of appropriate management tools to deal with those challenges are hard to find. Water resources in Nepal are therefore vulnerable due to resources stress, development pressure and subsequent increase in demands, ecological insecurity, and management challenges (Pandey et al., 2012).

Inadequate access to water is impacting differently among the sectors and income levels. For example, lack of safe drinking water and sanitation are the major issues for poor people. Water scarcity for poor people, therefore, is not only about droughts or rivers running dry, but also threatening their rights for the fair and safe access to water needed to sustain their lives and livelihoods. Decreased runoff will make it harder to improve access to safe drinking water, which leads to additional costs for the water supply sector and higher socio-economic impacts and follow-up costs. In the areas where water-induced extreme events become more intense

and more frequent, the socio-economic costs of those events will increase significantly. Poor communities can be particularly vulnerable in such areas.

Any substantial change in the frequency of floods and droughts, or in the quantity and quality of water or seasonal timing of water availability, will require adjustments that can be costly in monetary terms as well as in terms of societal and ecological impacts. Increased risk of food security, water shortage for industries and societies, decrease in hydropower generation, natural hazards like floods and landslides and potential migrations caused by them are some of the likely reasons that make different sectors vulnerable. Enhanced melting and increased length of the melt season of glaciers leads at first to increased river runoff and discharge peaks, while in the longer time-frame, glacier runoff is expected to decrease. The future socio-economic pathways will most likely increase the future water demand resulting in widening gap between water supply and demand, which will further exacerbate the existing water stress particularly during dry season (Chaulagain, 2015). As different locations and basins have their own biophysical, socio-economic, and institutional-policy characteristics, sources of vulnerability of water resources in various locations are likely to be different. For example, a study by Pandey et al. (2012) showed that medium river basins in Nepal are more vulnerable than large river basins. In large basins, vulnerability of water resources is mainly due to lack of management capacity followed by resources stress and less related to development pressure. In case of medium basins, due to their relative locations, sources of vulnerability are different in different basins.

In case of future vulnerability, increased temperature will affect the annual glacier mass balance and change precipitation pattern, i.e., more rainfall and less snowfall. Rainfall, unlike snowfall, will not be stored in the mountains, but will immediately be drained out from the basin resulting in less ground water recharge upstream and more floods downstream during the monsoon. Therefore, projected change in climate is likely to exacerbate the vulnerability of water resources from various angles, such as increased risk of flash floods following glacial lake outbursts. MoEST (2012) has revealed that the water-induced disasters in Nepal are increasing in terms of magnitude and frequency. Likely changes in the river flows in the future vary widely from river to river; the rain-fed rivers are likely to have a decreasing trend during lean seasons and an increasing trend during rainy season; and magnitude of the change is expected to be relatively high in rain-fed rivers compared to the snow/glacier-fed rivers. Early shift of the hydrographs might also be possible (Chaulagain, 2016). All the aforementioned phenomena will render water resources more vulnerable and impact the normal water withdrawal pattern of the river. Furthermore, in terms of vulnerability to GLOFs, different districts are likely to have different degree of vulnerability. Ranking of the districts based on vulnerability to GLOF impacts identifies six districts as very highly vulnerable, six more as highly vulnerable, and seven as moderate (Figure 5-9).

5.5.3. Adaptation Measures to Reduce Vulnerability

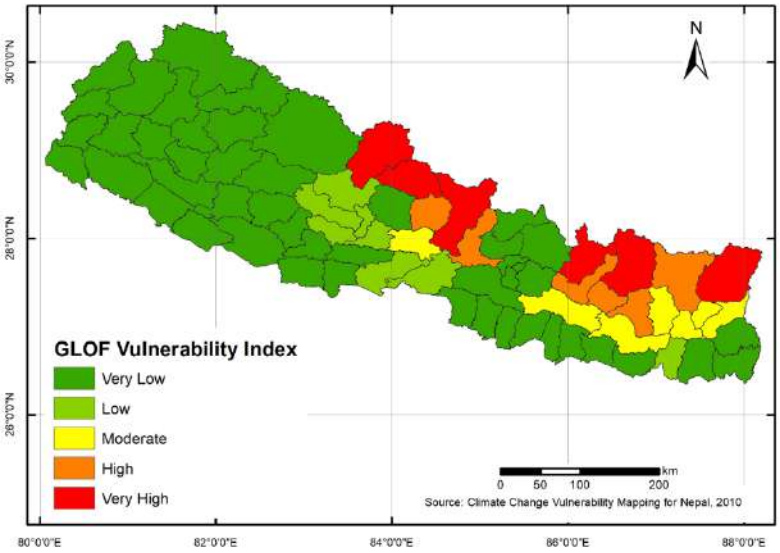
Technological measures have been applied to reduce vulnerability of climate change on water resources.

Early Warning Systems

Nepal has 282 meteorological (DHM, 2018a) and 51 hydrological stations (DHM, 2018b). Based on the data and information from these stations, a number of early warning systems have been set up to forewarn the communities. For instance, DHM has set up a GLOF early warning system downstream from Tsho Rolpa Glacial Lake in the Tama Koshi River basin in eastern Nepal.

Similarly, efforts are made to develop a web-based telemetry system in various rivers to provide real-time data and information on water levels and provide flood warnings to various stakeholders. DHM has upgraded 11 hydro-meteorological stations in the Koshi River Basin to improve flood forecasting and early warnings in real time.

Figure 5-9: GLOF vulnerability ranking of different districts in Nepal



Glacial Lake Lowering

To reduce the risk of GLOF incidence from the potentially dangerous glacial lakes, in 2016, the DHM has reduced the water level (3.4 m) of Imja Glacial Lake (Sharma, 2017). Further, the DHM had lowered Tsho Rolpa Glacial Lake by 3m in 2000 (Shrestha et al., 2004) through the construction of drainage channel for controlled discharge of water.

Climate-Resilient Water and Energy Infrastructures

Two potential options for adapting to hydro-energy sector could be (a) retrofitting existing ones to reduce the risks of climate variability on current plants and (b) over-design new plants to mitigate against all possible risks such as design to cope with the most extreme climate scenarios. Early adaptation (to future climate change) has the potential to increase the costs of capital or operation of hydropower plants, and affects the rate of return for the entire project period. However, the benefits of these investments in terms of reduced damage from climate change will arise in long-term. The effective adaptation depends not only in identifying appropriate option and investing, but also on understanding the institutional context and barriers and addressing them.

5.6. Forests and Biodiversity

5.6.1. Overview of Forests and Biodiversity Sector

Nepal occupies a unique geographic position on the Earth, possessing high elevation and climatic variations which ranges from 59 m to 8,848 m (the highest point in the world) in a short distance of150-250 km along north-south transect. As a result, Nepal has rich diversity of flora and fauna (MoFSC, 2014). Nepal is also considered a crossroad of plant migration in the Himalayan region, lying between drier Western and Central Asiatic floral provinces, a more humid Sino-Japanese province, South East Asiatic elements penetrating into the foothills of Eastern Nepal, African-Indian desert elements towards the western part of Nepal, and typical

Indian floristic elements in the southern part (Welk, 2016). Its vegetation types include tropical lowland rain forest (*Shorea robusta* forests), temperate forests of oak and conifers in the mid hills to dwarf scrubs of rhododendron and alpine meadows in the higher regions (MoFSC, 2014; Miehe et al., 2015). As a consequence, Nepal has 118 different ecosystems with 75 vegetation types, providing ecosystem goods and services (MoFSC, 1995).

Nepal occupies about 0.1% of the global area, but harbours 3.2% and 1.1% of the world's known flora and fauna respectively (MoFSC, 2014). This includes 5.2% of the world's known mammals, 9.5% birds, 5.1% gymnosperms, and 8.2% bryophytes. A total of 312 flowering plants, 160 species of animals (including one species of mammal), one species of bird, and 14 species of herpetofauna are reported to be endemic in Nepal. The richness of endemic plant species increases steadily from low to high elevations. The high-altitude rangelands are especially important from the perspective of endemism (MoFSC, 2014, Tiwari et al., 2019). The first systematic classification of phyto-geographic boundaries based on climate, vegetation and floristic composition has classified Nepal's forest into 35 types (Stainton, 1972). These types are often categorized into 10 major groups; i) tropical, ii) subtropical and broadleaved, iii) subtropical conifer, iv) lower temperate broadleaved, v) lower temperate mixed broadleaved, vi) upper temperate broadleaved, vii) upper temperate mixed broadleaved, viii) temperate coniferous, ix) sub-alpine, and x) alpine scrub (MoFSC, 2014).

Although the forest assessment report of the GoN has indicated overall increase in forest cover in comparison to that of 1980; there has also been substantial forest cover decline in areas of Terai and Chure as well as western Nepal (DRFS, 2015). Climatic changes have significant impact on forests of lowland as well as mountains in terms of forest composition, tree biomass production and range shift of tree species; hence the understanding of the interactions among forests, climate, water resources, and human activities is essential in advancing actionable science and developing robust climate change mitigation and adaptation strategies and methodologies globally as well as regionally.

5.6.2. Vulnerability and Impact Assessment

Impacts

Forests and biodiversity constitute a sensitive thematic sector in Nepal as identified both by NAPA (2010) and NAP (2017). Nepal has seen the impacts of changing climate, especially in high mountains, mid hills and low lands. Some of the impacts of climate change on forests and biodiversity in Nepal are (i) shifts in agro-ecological zones, prolonged dry spells, and higher incidences of pests and diseases, (ii) increased temperature and rainfall variability, (iii) increased emergence and quickened spread of invasive alien plant species, (iv) increased incidence of forest fire in recent years, (v) changes in phenological cycles of tree species, (vi) upward shifting of treeline in the Himalaya, and (vii) depletion of wetlands (MOSTE, 2010).

Similarly, rapid biological invasion of new alien and invasive species is emergent (MoFSC, 2014). Extreme climatic conditions have also led to increased incidence of forest fire affecting human as well as productive forestland, increased disaster risks such as urban flood, lightening, landslide, hailstorms etc. Seasonal changes have also been observed in terms of early sprouting, flowering and fruiting. National Biodiversity Strategy and Action Plan 2014-2020 of Nepal outlines following climate change impacts in the forests and biodiversity sector.

a) The climate range of many species will move upwards in elevation from their current location. This will have different effects on species. Some species will migrate through fragmented landscapes whilst others may not be able to do so.

b) Many species that are already vulnerable are likely to become extinct. Species with limited climate ranges and/or with limited geographical opportunities (e.g., mountain top species), species with restricted habitat requirements, and/or small population are typically the most vulnerable.
c) Changes in frequency, intensity, extent and locations of climatically and non-climatically induced disturbances will affect how and at what rate the existing ecosystems will be replaced by new plant and animal assemblages. The High Himalaya and High Mountain ecosystems are likely to be worst affected by climate change. Among the natural habitats, remnant native grasslands are highly vulnerable to the impacts of climate change (BCN & DNPWC, 2011).
d) The impacts of climate change are likely to increase in future, which will not only affect biodiversity but also livelihoods of millions of local and indigenous people who depend on biodiversity. Disruption of ecological services on which they depend due to climate change is expected to especially affect the poorest and most vulnerable communities.

a) Impact on Forest Ecosystem

Plant species are vulnerable to climate change in all ecological zones of Nepal. High mountain forests have already shown their response to increasing warming and altered environmental conditions in Nepal, upward shifting of treeline has been observed for species such as *Abies spectabilis* and *Betula utilis* (Gaire et al., 2017, Tiwari et al., 2017a, Sigdel et al., 2018). This shift of ecological zone along with competition with existing species has made some tree species like Birch (*Betula utilis*) and Taxus (*Taxus baccata*), Cedar (*Cedrus deodara*) highly vulnerable (MOFSC, 2011). In Trans-Himalayan zone of Mustang, the warming induced growth decline has been reported for *Betula utilis* (Tiwari et al., 2017b), which may reduce the reproductive performance and affect survival of the species in the region.

Mountain plants are highly likely to be affected by overall warming with changes in precipitation pattern (MoFSC, 2011). Fringe forests are more vulnerable to landslides. In case of mid hills, trees species such as Banjh (*Quercus lanata*), Kharsu (*Quercus semecarpifolia*), Katus (*Castanopsis indica*), Champ (*Michelia champaca*) are becoming more vulnerable due to rise in temperature. Upward shifting has also been experienced in trees like utis (*Alnus nepalensis*). Similarly, diseases such as stem borer (Benikira) and Aijeru or mistletoes (*Scurrula* sp.) have been reported in fodder trees like *Ficus sp*. Farmlands have been infested by defoliator resulting ultimate death of trees. Another insect named Guheykira (*Scarabaeoida* sp.) has also been found to be infested in Banjh (*Quercus leucotrichophora*) and Painyu (*Prunus cerasoides*).

In Terai, Sal (*Shorea robusta*) trees have been infested by caterpillar during March-May. Due to prolonged seasonal drought, incidences of forests fires are increasing, and plants with broad-leaves are prone to fire and cannot thrive in stress conditions (MoFSC, 2014). Invasion and rapid expansion of some alien species, such as *Mikania micrantha*, *Ageratina adenophora* (syn *Eupatorium adenophorum*), *Chromolaena odorata* and *Lantana camara* has emerged as a major threat to forest biodiversity especially in case of degraded land (Thapa et al., 2018). For example, *Mikania micrantha* is a climber that spreads extremely fast over forest canopy, and blocks sunlight for native plants, and eventually kills them or stunts their growth. Its invasion has been a serious problem in the forests and grasslands of the Chitwan Valley (Shrestha & Dangol, 2014) and the Koshi Tappu Wildlife Reserve and many other areas in the Terai, Siwalik and Middle Mountains (MoFSC, 2014).

b) Impact on Rangeland Ecosystems

In high altitude, due to climatic stress such as less water, and change in weather patterns, vegetations in the high-altitude rangelands are more vulnerable. There has been a decrease in availability of medicinal plants, such as Yarshagumba (*Cordiseps sinensis*), Jatamansi (*Nordostachys grandiflora*), Kutki (*Neopicrorhiza scorphulariflora*) and Sugadhawal (*Valeriana wallichii*). This threatens the livelihoods of indigenous and local populations. In mid hills, there has been decline in herbal fruits, such as Amala (*Phylanthus emblica*), Ritha (*Sapindus mukrossi*), Timur (*Zanthoxylum armatum*), Bel (*Aegle marmelos*), Satawari and Sugandhakokila (*Cinnamomum glaucescens*). Similarly, the production of other non-timber forest products such as Nigalo (small bamboo), bamboo, mushroom and rattans have also declined. In Terai region, there also has been changes in temperature and water related characteristics, affecting herbs like Kurilo (*Asparagus recemosus*), Pipala (*Piper longum*), Dalchini (*Cinamomum zeylanicum*), Kaulo (*Cinamomum sp*) to their decline in the forests and making them more vulnerable to both climatic changes and anthropogenic pressure.

c) Impact on Wetland Ecosystem

Nepal has one of the world's most treasured water systems including Ramsar sites. Wetlands are an integral part of the ecosystem that regulate water and have a unique role in maintaining the food chain; they are also habitats for several species of wildlife, including migratory birds, in the high mountains and lowland plains. Hence wetlands function as a corridor connecting aquatic and terrestrial ecosystems. Wetlands are particularly vulnerable to climate change, human pressure including changes in land cover and land use patterns. They are unable to migrate and, hence are vulnerable to changes in hydrology and nutrient inputs (MoFSC, 2014). Invasion of water hyacinth (*Eichhornia crassipes*) is a major threat to tropical and sub-tropical wetlands. Many internationally important wetlands, including the Beeshazari Lake in the Barandabhar corridor forest in Chitwan and Phewa Lake in Pokhara, are already severely invaded by it. The plant grows fast and covers the entire water surface. The reduction in light and air reaching below the surface due to the invasion affects aquatic organisms. *Ipomoea carnea* and *Mikania micrantha* are also becoming abundant around wetlands, thereby affecting habitats of dependent fauna.

d) Impact on Agro-biodiversity

Nepalese agriculture is predominantly small-scale and heavily dependent on natural rainfall. Nepal's economy relies on subsistence farming and faces risk due to change in the amount of stream flows, intense and erratic monsoon rainfall, and the impacts of flood (MoE, 2010). Hailstorms are the most frequently occurring climate-induced disaster during the months of March/April and October (GoN, 2011). Although most of the hail is relatively small in size, there have been cases of larger hail stones, causing extensive damage to standing crops and even inflicting injuries and death. Major damage from such storms has been recorded in eastern Nepal (1980) and mid-western Nepal (1983). Hailstorms damage summer as well as winter crops, especially in the mountainous areas of the country.

In addition, climate change is likely to exacerbate these impacts (MoSTE, 2014b). The production of buckwheat, which comprises almost 30% of the total crop production in Mustang district, has been affected in recent years due to higher level of warming. The time duration of growing buckwheat has also increased and productivity had declined with the increase of pests among others (MoSTE, 2014b). Similar incidents indicate shade conditions and temperature

affect the viability of pollen and seed and bud formation is reduced as temperature increases (Wang & Campbell, 2004).

Impact on Faunal Diversity

Changes in climatic factors and associated impacts in and around high-altitude forests has led to limitation of food and habitat for local and migratory birds like Danphe pheasant (*Lophophorus impijanus*). As a result, the population of migratory birds like domicile crane (*Anthropodis virgo*) and other birds are already declining. In high altitudes, high-altitude animals have started to migrate. For e.g., Pikas (*Ochotona* sp.), habituated mostly around 2800 m, but has migrated up to 3200 m altitude. Similarly, leopards are now seen at higher altitudes. In mid hills, water stress has led to decrease in a numbers of local bird species such as dove, Bhyakur (*Bablar* sp.), ducks, vulture, eagle and bat. Early flowering and early fruiting in plants also make birds vulnerable due to change in food availability. Due to shortage of water, the number of deer, monkey, porcupine, and pangolin is decreasing. Red monkeys earlier found in Chure range are now seen in Mahabharat range. Increased water scarcity in Terai has led to decrease in number of peacocks, water ducks, and Mynah. Birds like Kilhat and migratory birds like Malchari are decreasing in and around forests. In 2010, an alarming number of 149 bird species (17%) of Nepal's birds was considered nationally threatened, out of which 61 were thought to be Critically Endangered, 38 Endangered and 50 Vulnerable. An additional 16 species were considered threatened in 2010 compared to 2004. Over half of these threatened birds inhabit forests, with over a quarter in wetlands, and smaller numbers in grasslands (Nepal's Birds, 2010).

Vulnerability

Vulnerability and risk assessment for Nepal's NAP process mentioned that indicators for vulnerability are drawn from the sector's sensitivity and adaptive capacity. Sensitivity indicators for biophysical elements include forest growth, productivity, and species distribution; bottlenecks for faunal migration; habitat fragmentation, and pressure on forest and biodiversity resources, and phenological changes. The sensitivity indicators for forest dependent communities include the economic status of households, extent of dependence on forest resources, and gender and ethnicity (MoPE, 2017a). Upward shifting of ecological belts is expected with the rise in temperatures (Gaire et al., 2017; Tiwari et al., 2017a; Sigdel et al., 2018) as in case of high mountain tree species like *Abies spectabilis* and *Betula utilis* in Nepal Himalaya.

However, upward movement of species will be limited due to adverse environment for their growth (e.g., soil and moisture conditions) and biological interactions (Liang et al., 2016). Upper tree line vegetation should primarily move upslope in the mountains due to warming, owing to the altitudinal temperature gradient, as has been frequently documented during the recent decades (Kelly & Goulden, 2008; Gottfried et al., 2012). The mountains usually have conical shape; hence the upslope movement inevitably results in range loss and may even lead to 'mountain-top extinctions' (Colwell et al., 2008) in extreme cases.

High altitude species, such as Birch, *Jatamansi*, *Kutki* are likely to become more vulnerable with increase in climatic and human induced stresses along with biotic interaction among species. Similarly, the habitats of mountain fauna such as snow leopard are increasingly threatened due to increased temperature. Reduced snowfall, untimely rains, and increased dryness have altered the flowering and fruiting behavior of plants which is closely related to the survival of wildlife. When seasons of food availability change, it changes the periodicity of life cycles of animals and

insects such as reproduction, migration, and hibernation. This results into serious vulnerability for wildlife and possesses a huge threat to the people who depend on biodiversity for their livelihoods (MoSTE, 2010). Due to being climate sensitive sectors, there is dire need of intensive studies for vulnerability and risk assessment of forest and biodiversity sectors to reduce the climate risk.

5.6.3. Adaptation Measures to Reduce Vulnerability

The GoN is making efforts to reduce the vulnerability and impacts of climate change on forests and biodiversity. There has been a strong policy-legal framework for biodiversity conservation, climate change adaptation, and mitigation measures. There have been initiatives on forest fire control programme in all districts. Integrated Chure Conservation Programme has been initiated to reduce the vulnerability of the area, and various in-situ and ex-situ conservation activities have been undertaken to protect endangered, threatened and rare wild life (MoFSC, 2014). Similarly, the mountain landscape management programme and the Terai Landscape Management and Conservation programmes are initiated to promote biodiversity conservation at the ecosystem levels, both on protected and productive areas by involving local institutions.

Nature Conservation National Strategic Framework for Sustainable Development, 2015-2030 (NPC, 2015) intends to promote nature responsive development and thereby contribute to achieve sustainable development goals which ultimately address climate smart initiatives. The framework serves as an umbrella strategic framework in order to guide sectoral agencies on nature-responsive development along with improving accountability on nature conservation. The framework has five strategic pillars: 1) Mainstream nature conservation in development efforts, 2) Harmonize sectoral policies and strategies, 3) Strengthen coordination among sectoral bodies, 4) Valuing and accounting ecosystem goods and services on investment decision, and 5) Improving accountability on conservation.

In a nutshell, activities to reduce the vulnerability of climate change on biodiversity and forest ecosystem include: sustainable and scientific forest management through watershed and landscape level planning and management, improved governance capacity, low cost soil and water conservation practices; control of forest fire; effective implementation of forest and biodiversity conservation legislation, proper monitoring of forest health through management of landscape-level ecosystem and corridor, improved ecological connectivity, restored ecosystem and species, and control of invasive species; increased understanding of changes in habitat with intensive study; emphasis on management of herbs; ex-situ conservation of threatened species; afforestation/reforestation and reduction of deforestation and forest degradation; improved protected areas in mountains; reduced anthropogenic stresses; provision of minimum flow water requirement in river for fish and aquatic species; awareness raising, capacity building and technology transfer; incentive for private landowner, strengthening the early information system of climate variability and implementing the preparedness measures to reduce the risk of climate induced disasters.

5.7. Public Health and WASH

5.7.1. Overview of Public Health Sector

The Constitution of Nepal guarantees the rights to free basic health care services, right to information regarding medical treatment, equal access to health services, and access to clean drinking water and sanitation. Health care system in Nepal is based on primary health care (PHC), which was adopted after Nepal became signatory to the Alma Ata Declaration (1978).

Nepal Health Sector Strategy (NHSS) commits to of equitable access to health services, quality health services, health system reform, and a multi-sectoral approach (NHSS, 2015). Currently, the Department of Health Services is responsible for the delivery of health care services.

As Nepal moves into a federalism, the onus of health care delivery falls separately to the Federal, Provincial and Local government. In terms of service, the primary tier are community health centres, primary health care centres, urban health promotion centres, primary health centres; at the secondary tier are municipal and village health offices with tertiary level referrals to Provincial and Federal level specialized hospitals (PPICD, MoHP, 2017; Table 5-18).

Furthermore, climate change has made water sources vulnerable to deplete or dry out rendering water services, including for sanitation, inadequate or defunct. One third of the water supply projects in Nepal are not functional and climate change is identified as one the critical reason behind this. In other cases, disasters like floods and landslides triggered by heavy rains will lead to contaminated drinking water and public health crises like cholera or typhoid outbreaks.

Table 5-18: Snapshot of the Health Sector

SN	Hospitals types	Number
1	Private hospitals	301
2	Zonal hospitals	10
3	District public health offices	26
4	Districts and other hospitals	83
5	District health offices	49
6	Primary health care and health centres	202
7	Health posts	3803
8	Female community health volunteers	51,416
9	Primary health Care outreach clinics	12,660
10	Epi-outreach clinics	16,134

Source: DoHS (2017); CBS (2014)

The intensity and duration of floods in Nepal, especially in the Terai during the monsoon, have increased drastically over recently years. These affect several districts and provinces, resulting in yearly cases of cholera, especially in urban areas, including the Kathmandu Valley.

5.7.2. Vulnerability and Impact Assessment

Health sector performance and outcomes are influenced by multiple determinants, including climate change. Studies on the association between climate factors and reported cases of health issues have shown that the diseases and health-related hazards are increasing in the country. There are reports showing association between the incidence of climate-sensitive diseases and changes in temperature and precipitation trends (examples, Pradhan, et al., 2013; Dhimal et al., 2014; Regmi et al., 2016; Dhital et al., 2016).

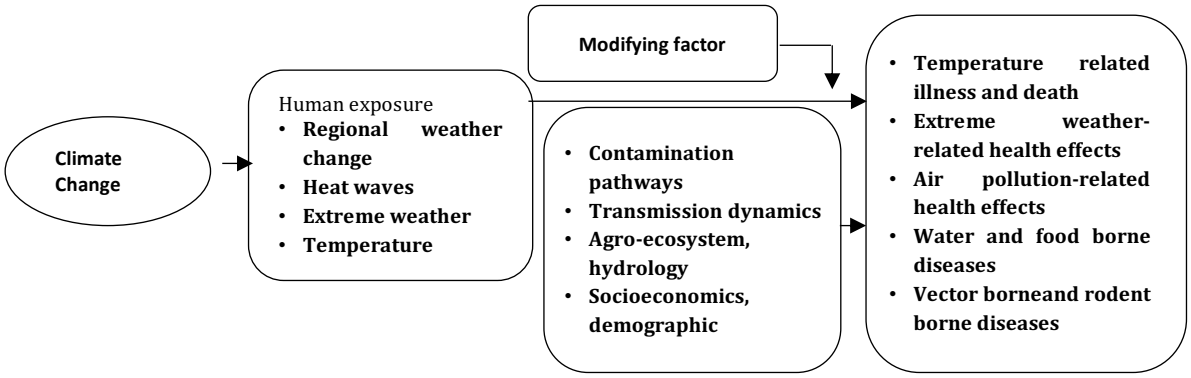
Impacts

Human health is affected by various physical and biological system of the earth along with climatic system (Figure 5-10). Climate change is thus a major addition to the variety of environmental health threats encountered by people (WHO, 2003). The health of human populations is responsive toward the various aspects of climate change causing global burden of diseases and pre-mature death (IPCC, 2014b). The negative impacts of climate change are

augmented by factors such as widespread poverty, diseases and high population density, which are estimated to double the demand for food and water in the next 30 years (IPCC, 2007a). Changes in temperature and humidity play an important role on human health and some increased health risk are attributable to extreme weather conditions (Franchini & Mannucci, 2015). The implications of climate change to human health can be grouped into following six major categories (IPCC, 2007a):

i. Cardio-respiratory diseases
ii. Injuries
iii. Nutritional deficiencies/malnutrition
iv. Diarrheal diseases
v. Vector-borne disease and
vi. Psychological stress/diseases

Figure 5-10: Climate change and human health impacts



Source: Based on: Patz et al. (2000); Mc Michael et al. (2003)

Similarly, the impacts in human health due to climate change include an increase in cardiovascular disease mortality in tropical region; increase in the burden of diarrheal diseases in low-income regions, increase in heat-related mortality and morbidity (Dhimal, 2007). Nepal faces a triple burden of health problems: threats from disasters, adverse effects of climate change, accidents, violence, and injuries (MoH, 2015). The climate change together with health inequality and diseases is a major challenge to public health in Nepal (Ramin, 2009). Episodes of intense rainfall events can accelerate the flooding, which claims human lives. Flood is one of the most frequent disasters in terms of death tolls and economic losses (MoHA & DPNet-Nepal, 2015). Heat and cold waves have increased in various regions of Nepal where mortality and mobility due to heat waves has appeared (MoSTE, 2011).

a) Vector-borne Diseases

Malaria: Malaria is endemic to 65 districts of Nepal. It is evidenced that increase in annual maximum temperature makes vulnerable to the risks of malaria. About 13.02 million population of Nepal which is almost 47.9% of people live in malaria endemic regions (EDCD, 2017). Though there seems some control, new areas have been reported with malaria (DoHS, 2011) particularly in the context of mountains and uplands, the propagation of malaria is an indicator of climate change (Beniston, 2003). The number of cases of malaria reported in different years is given in Table 5-19.

Table 5-19: Mortalities due to malaria in Nepal

Year	2010	2011	2012	2013	2014	2015
Malaria cases	-	2,634	1,674	-	-	991

Source: DoHS (2017)

Dengue: Dengue is the most rapidly spreading mosquito-borne viral disease, showing a 30-fold increase in global incidence over the past 50 years (WHO, nd). The principal vectors for dengue, *Aedes aegypti* and *A. albopictus*, are climate sensitive (IPCC, 2014) and the evidence of the presence of dengue vector *A. aegypti* in Kathmandu valley shows that it may be attributed to increased temperature creating favourable environment for mosquitoes which was traditionally not found in that region (Dhimal & Bhusal, 2009). Dengue fever showed its major outbreak in Nepal in the year 2010 in the Central part of Nepal (Sedhain et al., 2012). The number of cases of dengue fever across different year is represented in Table 5-20.

Table 5-20: Mortalities due to dengue in Nepal

Year	Number of Case	Death
2010	917	5
2011	79	0
2012	183	0
2013	785	0
2014	302	-
2015	134	-

Source: DoHS (2017)

b) Diarrheal Disease

Increase in extreme weather events (extreme heat, drought or rainfall) caused by climate change have been strongly linked to the incidence of diarrhoeal disease (Chou et al., 2010). Diarrhoea increases by 8% for each 1ºC increase in temperature, increasing the number of patients with the rise in temperature (Checkley et al., 2000). Diarrheal disease accounts about 3.3% of total death in Nepal (WHO, 2012). The major role of climatic phenomena is the delivery of conditions favourable to the propagation and transmission of pathogens (Colwell, 1996). Bhandari et al. (2013) found that there is strong significance between diarrheal cases occurrence and temperature and rainfall. The classification of diarrheal diseases is represented in Table 5-21, which includes incidence and case fatality of diarrhoea among children under 5 years of age.

Table 5-21: Incidence and case fatality of diarrhea among children under 5 years of age

		Region					
Indicators	**Year**	**EDR**	**CDR**	**WDR**	**MWDR**	**FWDR**	**National**
Estimated <5-year population that are prone to diarrhoea	2014/15	579,372	981,253	482,756	450,398	314,400	2,808,179
	2015/16	604,096	1,019,943	508,025	400,118	287,878	2,820,060
	2016/17	635,097	1,102,200	534,361	400,270	287,251	2,959,179
Incidence of diarrhoea/1000< 5 years population	2014/15	655	482	538	749	1,009	629
	2015/16	481	377	414	693	873	501
	2016/17	407	315	338	634	724	422
Diarrheal deaths	2014/15	3	4	7	16	6	36
	2015/16	26	16	3	24	11	80
	2016/17	18	43	6	7	15	89

Source: DoHS (2017)

Vulnerability

Climate change can affect the public's health in a number of ways, from causing direct health impacts to indirect impacts because of change in vector transmitters (Ministry of Health, 2015). Diseases like malaria (Beniston, 2003), dengue (Dhimal & Bhusal, 2009), diarrhoea (Checkley et al., 2000) are affected by climatic phenomena. The exposure of Nepal's public health to the impacts of climate change is summarized as follows:

- The occurrence of cold waves is increasing in Terai region with the total death of about 822 from the year 1974-2014 (MoHA & DPNet-Nepal, 2015). Every year, various parts of Nepal, mainly in Terai region, experience high temperature during the months of March to June with the higher temperature in the decade 2001-2010 (MoHA & DPNet-Nepal, 2015).
- Similarly, decrease in food production possesses a threat of insufficient nutrient.
- Change in temperature and precipitation increases the risk of diseases (Ministry of Health, 2015). It involves the ecosystem-mediated impacts of climate change or indirect impacts from environmental and ecosystem changes, such as shifts in patterns of disease carrying mosquitoes and ticks, or increases in waterborne diseases due to warmer conditions and increased precipitation and runoff (IPCC, 2014). Global warming can extend the geographic areas capable of sustaining transmission of vector borne diseases like malaria (Narain, 2008).

Furthermore, people living in flood and landslide prone zones or dense urban areas are exposed to higher risks of disease outbreak (MoE, 2010). The chances of vector-borne and water-borne diseases are higher in some areas rather than others (Dhimal et al., 2017). Additionally, most of the mortality from heat-waves are related to cardiovascular, cerebral-vascular and respiratory causes, and is intense in the elderly population and those with lower immunity. The projected effects of climate change include a wide range of health problems (Box 5-2).

Box 5-2. Projected health effects of unabated climate change in Nepal

- Greater risk of injury, disease and death, owing to more intense heat waves, cold waves and forest fires
- Increased risk of undernutrition, resulting from diminished food production in resource-poor regions
- More negative health consequences of lost work capacity and reduced labor productivity in vulnerable populations
- Increased risk of vector-borne, waterborne and foodborne diseases, especially in mountain areas, and leading to perennial occurrence in the lowlands
- Increase in cardiorespiratory diseases, owing to higher ambient air pollution and haze in urban areas, resulting from climate change
- Increase in mental health problems, owing to extreme climatic events such as droughts, floods and landslides
- Modest reductions in cold-related mortality and morbidity in the highlands, owing to fewer cold extremes
- Increased morbidity and mortality related to cold waves in the southern Terai lowlands
- Reduced disease-transmission capacity of vector insects in the Terai, owing to higher temperatures exceeding their thermal thresholds.

Source: Dhimal et al. (2017)

The sensitivity to the impact of climate change differs for individual and community levels. At the community level, the resources available to cope with the impacts play an important role, whereas age and gender of person determine sensitivity in individuals (MoH, 2015). Women are mainly responsible for providing water in households; water scarcity increases their workload, limiting their personal and social development, and exposing them to poor sanitation or personal hygiene (Dhimal, 2015). The vulnerability of different genders can be attributed to socio-cultural factors such as decision-making capacity and control over resources (MoE, 2010). Similarly, changes in climate variables may reduce the quantity and quality of food, ultimately undermining health outcomes with compromised nutrients intake.

5.7.3. Adaptation Measures to Reduce Vulnerability

Climate change has severe impacts on the human health and the sector requires effective adaptation measures (Haines et al., 2006). National malaria control programme (2009) resulted to a significant decrease in the cases of malaria from 1,674 in 2013 to 991 in 2014 throughout the country (DoHS, 2017). To reduce vulnerability and enhance adaptation, the GoN has adopted strategies with the following objectives (MoH, 2015):

- Raising public awareness about climate change and its effects on health;
- Generating evidences on health effects of climate change at national and sub-national levels through research and studies;
- Reducing the morbidity and mortality of infectious diseases (vector, water, air and food-borne diseases) and malnutrition attributed to climate change;
- Managing the risks of extreme climatic events; and
- Protecting human health from climate change through multi-sectoral response ensuing health in all policies.

In line with the strategies, the GoN has prepared National Climate Change Health Adaptation Strategies and Action Plans of Nepal (2016-2020) (MoH, 2015). It aims to develop the national strategies on climate change and health with an adequate focus on health sector and inter-sector collaboration for protecting health from adverse effects of climate change. The action plans are guided by the Constitution of Nepal 2015, National Health Policy of Nepal 2014, Health Sector Adaptation Strategy (2015-2020), National Population Policy 2014 as well as National Climate Change Policy 2019, and is a step forward in mainstreaming health in overall national adaptation plan (NAP). The strategy aims to reduce vulnerability and to enhance adaptation measures to reduce adverse effects of climate change on human health. It has proposed various measures for the reduction of vulnerability and reduce the risk to the vulnerable population (Table 5-22). Different types of control strategies are being adopted for the mitigation of water, air, food and vector borne diseases. Various programmes such as immunization, awareness enhancement, vaccination help in reduction of the vulnerability. Another effort for the reduction of the vulnerable population toward risk includes training community health volunteers (CHVs) for the treatment of diarrheal disease which was seen effective in control of diarrhoea.

Table 5-22: Adaptation measures for the exposures and diseases in public health sector

SN	Exposure	Diseases	Adaptations
1	Water Quality, food quality, change in precipitation pattern	Water borne diseases; food borne diseases	Sanitation, Personal hygiene, nutrition
2	Heat wave and Cold wave	Heat stroke,	Awareness, Housing and basic for protection from heat and cold

SN	Exposure	Diseases	Adaptations
3	Air pollution	Cardio-respiratory mortality, ARI, Respiratory diseases	Monitoring of the emissions, Awareness to public, Use of protection measures
4	Flood induced health issues	Snake bite, drowning, injury	Housing settlement management

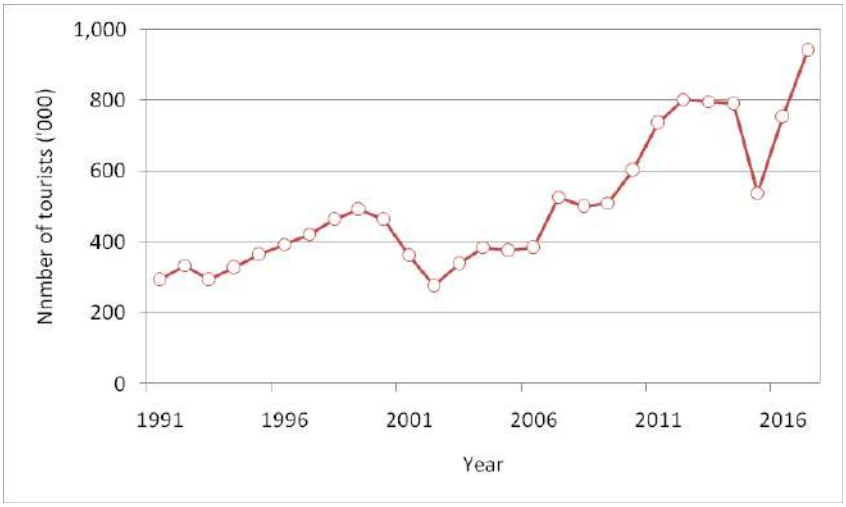
Cost-effective adaptation measures are available in the sanitation sector. A report by the World Health Organization and the Department for International Development[1] notes that waste and sanitation systems that use less water can be well adapted to climate change and demonstrate higher resilience. The Ministry of Water Supply (MOWS) and the Department of Water Supply and Sewerage Management (DWSSM) have adopted water source conservation, rain water harvesting, ground water recharge, water optimization and multiple use of water, as part of a principle of integrated water resource management in the core working strategy. DWSSM has also drafted guidelines for addressing disaster risk management (DRM) and climate change within the water and sanitation sector.

5.8. Tourism, Natural and Cultural Heritage

5.8.1. Overview of the tourism sector

Tourism represents a small, but expanding industry in Nepal. In 2017, the number of international tourists visiting Nepal was 940,218, which is an increase of 25% compared to the previous year (MoCTCA, 2018). According to the Economic Survey by the Ministry of Finance 2016/17, the GDP was slightly above US$ 7 billion, with major contribution of agriculture (34%) and tourism accounting for 7.5% (MoF, 2017). The number of tourist arrivals over the period of 25 years is shown in Figure 5-11. Tourism industry contributes 3% of the country's total GDP. In 2015-2016, the tourism sector contributed over 427,000 jobs, which was 2.9% of total employment. With a stable government in the country, employment is expected to grow at least by 100% in the coming years (WTTC, 2017).

Figure 5-11: Total arrival of tourists in Nepal 1991-2016



Source: MoCTCA (2018)

[1]WHO. 2018. Guidelines on Sanitation and Health.

Furthermore, tourism is a vehicle for socio-economic development as a result of its potential to earn foreign exchange, create employment, reduce income and employment disparities, strengthen linkages among economic sectors, control outmigration of local youth, and help alleviate poverty (Kurk, 2009). The 2014 tourism employment survey identified a total of 138,148 persons directly engaged in the tourism sector in Nepal (MoCTCA, 2018). The World Travel and Tourism Council (WTTC) 2014 report indicated that travel and tourism in Nepal generated 504,000 direct jobs in 2012 (3.2% of total employment), and this figure was expected to grow to 536,000 (3.3% of total employment) in 2014 (MoCTCA, 2018). The GoN has put high priority for tourism sector through its goal "to contribute greater GDP growth and employment, reduce poverty and increase sustainable access to foreign exchange for national development" (MoCTCA 2015).

5.8.2. Vulnerability and Impact Assessment

Seasonality and environmental conditions which depend on the climatic variables largely influence tourism industry that directly or indirectly affect the economy and livelihoods of the tourism dependent entrepreneurs and communities. In addition, climate change induced disasters influence the tourism-related infrastructure and resources. The abrupt changes in climatic variables and extreme events can damage the health and safety of tourists and people directly involved in tourism activities. Receding snow lines, melting glaciers, increased frequency of cloudbursts, floods, and landslides have the potential to change the nature and quality of tourism sites and infrastructure (Sharma, 2011). In November 1995, avalanches caused 43 deaths (including foreign trekkers) in the Khumbu and Kanchanjunga areas. On 2nd January 1999, five people were swept away by an avalanche in Gorkha district. In November 2014, unseasonal snowfall and avalanches resulting from the effects of Cyclone Hudhud killed at least 43 trekkers and guides between 2005 and 2014, a total of 235 people lost their lives due to inclement weather in the country, including avalanches and snowstorms (MoHA & DPNet-Nepal, 2015). The changing climate will have adverse impact on tourism in Nepal increasing stress on the environment and bringing more risks than opportunities for economies based on tourism (K.C., 2017). Furthermore, mountaineering, trekking and rafting are the key tourist attractions likely to be adversely impacted by climate change.

Mountaineering: *Mountains* have been a major attraction of tourists in the world. In 2016, a total of 8,176 climbers were given permission by the Department of Tourism and Nepal Mountaineering Association (MoCTCA, 2018). The mountains, however, have been extremely vulnerable to changing climate and extreme events in recent decade. Some studies recently (e.g., Ballesteros-Cánovasa et al., 2018) have provided evidence that the warming in recent decades has increased frequency of snow avalanche in the Himalaya. Accelerated melting of snows and glaciers in the Himalaya would reduce the number of trekkers/mountaineers. Considering the average vertical lapse rate of 6.5 °C km^{-1}, the present glaciated area above 5,000 m is likely to be free of snow with an increase in temperature of 1 °C in the next few years. Similarly, an increase in temperature of 3-4 °C could result in the loss of 60-70% of snow cover from the Himalaya (Alam & Regmi, 2004). This will be the major cause of mountain landscapes losing their beauty that will adversely impact tourism industry.

Trekking: In recent years, Nepal is attracting over 200,000 trekkers annually. According to the National Trust for Nature Conservation officials, the total number of visitors for trekking in

Annapurna region was 114,187 in 2016. In the second popular destination, the Everest region, the number of tourists increased from 1,406 in 1971 to 37,124 in 2014 (Rai, 2017). However, the vulnerability to natural calamities, climate change impacts have evidently increased in the high mountains (UIAA, 2015). In October 2014, more than 32 people were killed and hundreds of trekkers were trapped at Thorong La (> 5000 m asl) by sudden snowstorm in Annapurna area. Similarly, the increasing incidents of low visibility may discourage the nature treks on one hand and flight cancellation on the other. For example, tourists travelling to Namche and beyond towards Khumbu often are stranded in Lukla due to bad weather as the flights are cancelled for days sometimes and it takes almost a week by road.

Rafting: Under the umbrella of Nepal Association of Rafting Agencies, there are at least 30 Rafting agencies providing water-rafting services. Most of the rivers originate from the glaciers and snow fed lakes in the Himalaya availing perennial source of water. The changing climate, specifically the increased temperature will contribute in the increase of water level; however, the associated disasters like floods and landslides will reduce the quality and current of the running water. The increasing melting rate of the glaciers in long run will ultimately collapse the flow and volume water.

An economic assessment of climate change impact on tourism (Practical Action Nepal, 2018) shows that the overall loss and damage on tourism GDP has increased from NPR 0.0778 billion in the period of 1985-1990 to NPR 1.4624 billion in the period of 2010-2015. The share of loss is higher from outdoor and adventure tourism and leisure and recreation tourism within the overall tourism sector. The overall seasonal maximum temperature in Nepal is projected to increase up to 4.5 °C in spring and 3.3 °C in summer, whereas the minimum temperature might increase up to 5.4 °C in winter and 3.4 °C in summer at the end of the 21st century (MoSTE, 2014b). This increased temperature has the possibility to enhance snow melting in high Himalaya, bring heat wave and heat related allergy in the destination affecting the outdoor tourism activities. Similarly, the overall annual precipitation in the country is projected to be decreasing by 2% of the baseline amount by 2020s. Overall, these will have direct impact to the tourism industry of the country.

5.8.3. Adaptation Measures to Reduce Vulnerability

Considering the climate vulnerability in tourism sector, recent study recommends a set of measures, including the application of weather and climate information system, sustainable tourism practice, supply chain management, tourism products diversification, policy reforms and exploiting the situation for immediate opportunity (Practical Action2018). United Nations World Tourism Organization declarations, further recommendations include: analysis and enhancement of understanding of the climate change in tourism sector in Nepal, international and regional cooperation to respond to the opportunities and challenges posed by climate change and mainstream climate mitigation and adaptation while conceiving plans for the resilient development of tourism sector.

5.9. Urban Settlement and Infrastructure

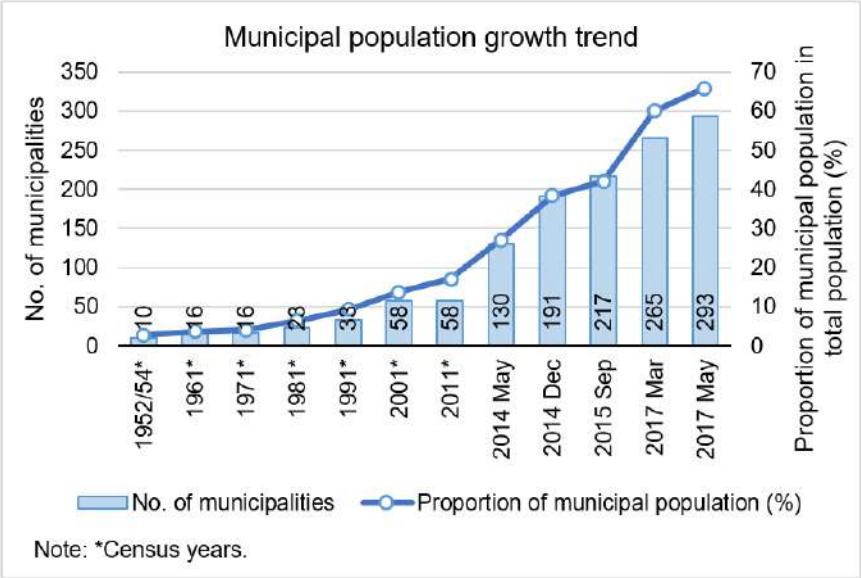
5.9.1. Overview of Urban Settlement and Infrastructure

Urbanization is a global phenomenon with more than half of the world population living in cities today with the urban population share expected to rise to 66 percent by 2050 (UN DESA, 2015).

Nepal is one of the most rapidly urbanizing countries in the world. Urban population is rapidly growing over the past two decades in Nepal (Figure 5-12). Urban population has increased from 9.2% in 1991, 17.1% in 2011 to 58.4% in 2017 with the restructuring of local government jurisdictions, identifying six metropolitan cities, 11 sub-metropolitan cities and 276 municipalities as urban areas (MoFALD, 2017).

Urban growth in Nepal is primarily characterized by (i) an increase in the number of municipalities, (ii) an expansion in the urban area, (iii) a relatively steady increase in the population of municipalities in the initial years, and (iv) a rapid increase in population in recent years (Subedi, 2014).

Figure 5-12: Municipal population growth trend.



Notes. The year labels in the horizontal axis are not proportionately spaced. Source: Joshi (2019) citing Subedi (2014), NPC (2016)

In 1981, 6.4% of the total population of the country lived in 23 municipalities. Between 1991 and 2011, the number of municipalities remained constant at 58, but the share of municipal population rose from 13.9 to 17.1% at the population growth rate of 3.38% per annum. At present, about two-third of the national population of the country live in its 293 municipalities. Figure 5-13 shows the changing number of municipalities, their population size and percentage share of the municipal population since 1952/54 census.

However, measuring urbanization in terms of municipal population has its limitations. In particular, with such definition, it becomes easy to overlook that most municipalities are still predominantly rural in character and that Nepal is still in an early phase of urbanization. However, municipalities are often the places where in-migration is high, and are likely to grow into towns and cities sooner than later due to expectations of public investment on infrastructure.

Urbanization in Nepal is primarily fuelled by rural-to-urban migration. Cities offer diverse economic opportunities which attract rural migrants including the poor. Cities have been hailed as drivers of economic growth, but urbanization in Nepal has been mostly haphazard.

Infrastructure and services in most municipalities, including old cities, lack adequacy, both in terms of quantity and quality. Numerous challenges exist in meeting even the basic needs of the burgeoning urban population, including housing, drinking water and sanitation, jobs, transportation, and healthcare, among others. In an assessment of basic urban infrastructure in old 58 municipalities conducted for National Urban Development Strategy 2017, only 26 (45%) municipalities scored 50 or more out of total 100 (MoUD, 2017).

Wide deficits and geographical disparities exist in the availability of basic urban infrastructure (e.g., housing, roads, water supplies and sanitations, sewage drainages, electricity, and solid waste management). According to Ministry of Urban Development (MoUD, 2017), only one-third of households in urban Terai have access to piped water supply as compared to 81% of households in urban hills. The quality and quantity of drinking water is insufficient in all urban regions. Likewise, slightly more than half of the urban households have access to sanitation system. Out of old 58 municipalities, only six have sanitary landfill sites and five practice-controlled waste dumping. The average road density in the urban areas is significantly low at 3.26 km/km^2. Lack of affordable housing is a major emerging concern in many urban areas, resulting into growth of squatter settlements and urban slums.

5.9.2. Vulnerability and Impact Assessment

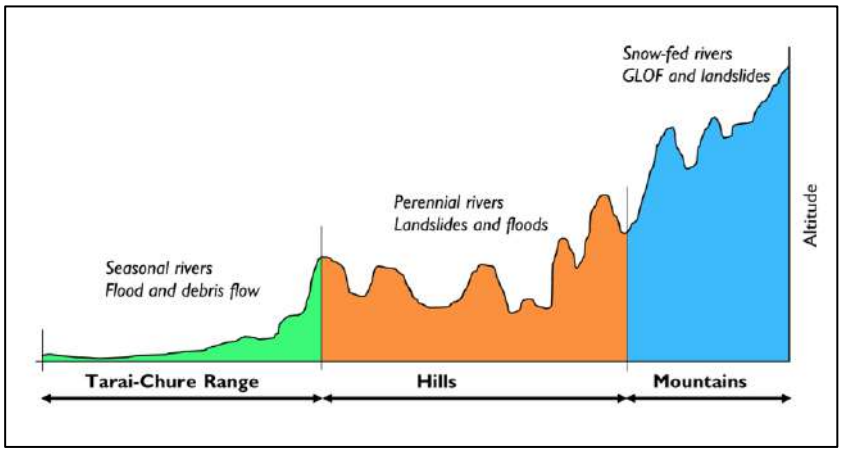
a. Impact and Vulnerability

The key indicators of climate change are rising temperature and erratic rainfalls. Both have direct effect on water resources on which human lives depend. Moreover, unusual weather patterns and rise in extreme events are putting urban settlements and infrastructure at increased risks. Increasing temperature, on the other hand, is melting small glaciers (< 1 km^2) rapidly causing them to near disappearance (Thakuri et al., 2014). This will eventually lead to water scarcity for irrigation and drinking purposes in the mountains and hills.

In the mid-hills, drying up of water springs has caused water scarcity even more pronounced particularly in dry seasons. In Terai, people have experienced decrease in river discharge as well as ground water table in dry seasons. The nature of rainfall has changed with an increase in the frequency of extreme events such as drought and torrential precipitation.

Many settlements in Nepal are built on risk-prone areas such as on steep slopes prone to landslides and riverbanks prone to floods. Occurrence of heavy and untimely rainfall has increased risks of landslides in high mountains, landslides and floods in middle mountains, and floods and debris flow in Terai (Figure 5-15). On top of that, informal settlements have grown rapidly in cities across Nepal, particularly along river banks. Thus, the poor people in these settlements are more vulnerable.

Figure 5-13: Schematic representation of Nepal's topography and hazards



Source: Joshi (2018)

Urban floods, dispersion of pollutants to water bodies, and outbreaks of water and vector-borne diseases are increasing in the cities during monsoons and heavy rains. Damage to roads and drainage structures poses huge economic loss as transport and daily lives are disrupted. Urban areas are mostly covered by built-up areas such as concrete and asphalt, both atmosphere and surface in the cities are warmer than in the rural areas creating 'urban heat island' effect. Increased temperature leads to health concerns, and puts pressure on energy use for cooling purpose.

Epidemics, which claim the most lives in Nepal (more than 50%), increase with overcrowded settlements exposing more population at risk (MoHA, 2011). Development of cites near the bank of river and change in precipitation pattern leads to decrease the ground water recharge mainly in urban areas where the ground is blocked due to concrete path. Similarly, increase in extreme rainfall may cause urban floods (Jha & Shrestha, 2013). In addition, built up areas create urban heat island which in general increases the heat of buildings through heating effect (Tromeur et al., 2012). This effect is seen in Kathmandu, where urban development contributes to higher city temperatures with the loss of vegetation in surrounding area, which further compounds heat island effect (Thapa and Murayama, 2010). Kathmandu metropolitan city is affected by some other potential factors like climate change and its associated disasters (Brown & Dodman, 2014) and more extreme weather conditions (DUDBC & MoSTE, 2014). The direct impact of climate induced disasters like damage of road or bridge by landslides or flooding is happening each year in Nepal (Revi et al., 2014).

National Urban Development Strategy (2015) recognizes climate change as a major risk factor, particularly in the context of urban poverty and the likelihood of increased numbers of people moving to urban areas due to disasters. The trend of migration will over-populate the informal settlements in urban areas (Patra & Terton, 2017). It leads to deficiencyin services to provide for the high rate of population increase, often resulting in a significant decrease in the cities' resilience (Unruh et al., 2005). Due to the construction of buildings, roads and other infrastructures, the agriculture land, forest and green spaces will decrease in urban areas, as a result, there will create food and water insecurity (Unruh et al., 2005).

Although the first impacts of climate change are on biophysical resources and physical assets, they lead to socioeconomic vulnerability. Rapid urbanization has been accompanied by growth

of vulnerable populations living in informal settlements. In most urban areas, low-income groups, whether informal settlers or not, face large climate change risks because of housing in slum conditions, tenure insecurity, poor accessibility to formal infrastructure and services. Table 5-23 summarizes primary and secondary impacts of climate change on urban settlements.

b. Adaptation Measures

Adaptation planning for urban settlements needs integrated approach, considering climate risks and hazards. It requires engagement of multiple stakeholders and adoption of community-based adaptation and ecosystem-based adaptation approaches (Revi et al., 2014). It also requires the implementation of urban plans and policies (Rimal, 2013) and enforcement of building codes (Patra & Terton, 2017). Vulnerability assessment of urban areas is vital (Rafael et al., 2015) for solving the environmental problems in coordination with research institution, planning and implementing institutions (UNFCCC, 2011). Table 5-24 provides a summary of adaptation measures to reduce climate change vulnerability regarding urban settlements and infrastructure in Nepal.

Table 5-23: Nature of climate change impacts on urban settlements and infrastructure

Climate Change Indicators	Primary Impacts	Secondary Impacts	Impacts on		
			People and Settlements	Roads and Transportation	WSS Systems
Increase in temperature	Melting of glacier and snow faster than accumulation	- Drying of springs	- Water scarcity		- Underperformance of WSS schemes reliant on springs
		- Increase in glacier lakes outburst flood (GLOF) risks	- Potential loss of lives and properties	- Potential damage to road infrastructure	- Potential damage to WSS infrastructure
		- Increase in forest area in higher altitudes	- Threat to local people from wildlife and wild fires		
	Desiccation of soil moisture	- Drying of springs	- Water scarcity		- Underperformance of WSS schemes reliant on springs
		- Lowering of ground water table	- Water scarcity - Increase in the cost to access ground water		- Underperformance of WSS schemes reliant on groundwater
	Increase in new disease vectors (insects and pests)	- Increase in vector-borne diseases	- Increase in health service costs, particularly in high-altitude settlements		
	Heat waves	- Increase in cases of heat stroke - Escalation of 'urban heat island' effect	- Increase in energy use and cost for cooling - Health problems, particularly for children and elderly - Disruption of	- Cracks in concrete and bitumen roads, resulting into potholes - Potential buckling of railway tracks	- Cracks in ferro-cement structures - Cracks in pipelines leading to water or sewer leakage - Damage to equipment in pumping stations

Climate Change Indicators	Primary Impacts	Secondary Impacts	Impacts on		
			People and Settlements	Roads and Transportation	WSS Systems
			economic activities		and treatment plants - Disturbances to biological process in septic tanks - Offensive odors from unmanaged solid waste
Deviation in nature of precipitation	No rainfall when expected	- No ground water recharge	- Rise in water insecurity		- Water scarcity
	Off-seasonal rainfall	- Water induced disasters as communities are ill-prepared during off-seasons	- Potential loss of lives and properties - Disruption of economic activities and daily lives	- Potential damage to road infrastructure - Traffic disruption - Poor visibility affecting driving safety	- Potential damage to WSS schemes
	Increase in intensive rainfall	- Increase in intensity and frequency of landslides, floods, flash floods, and urban floods	- Loss of lives and properties - Disruption of economic activities and daily lives - Entry of high waters into drainage system leading to back-flow and flooding in settlements	- Road erosion - Formation of potholes - Hill roads blocked or destroyed by landslides and mudslides - Poor visibility affecting driving safety - Bridge foundation scour due to water level rise.	- Blockage of drains discharging to rivers due to high water level and sediments - Sediment loads on source points - Sediment loads on intake structures raising operation and maintenance costs - Soil erosion around pipelines - Damage to pipelines (particularly in hills

Climate Change Indicators	Primary Impacts	Secondary Impacts	Impacts on		
			People and Settlements	Roads and Transportation	WSS Systems
					where large segments of pipelines cross rivers) - Reduction in reservoir capacity - Intrusion of rainwater with sediments into pumping stations and treatment plants - Overflow from septic tanks
	Rainfall instead of snowfall	- No snow deposition in the glaciers	- Fluctuation in regular flow volume of glacier fed rivers		
			- Damage to earthen structures (walls, roofs) by rain		
	Increase in hail		- Damage to buildings and physical infrastructures		

Acronym: WSS: Water supply and sanitation.

Source: Joshi (2017a) based on DUDBC & MoSTE (2014), DoR & MoSTE (2014), and DWSS, DoLIDAR & MoSTE (2014).

Table 5-24: Adaptation measures for urban settlement and infrastructure sector

Hazard	Objective	Current Situation	Futures Scenario	Adaptation Options
Floods	– Safeguard existing settlements and infrastructure lying on flood plains – Restrict settlement growth on flood plains	– Increase in the cases of torrential and sudden rains leading to floods and flash floods – Significant loss of lives and properties, particularly in Terai every year – Loss of farmlands affecting livelihoods – Haphazard settlement growth in flood-prone areas	– Increased flooding events to continue – Increased growth of settlements in flood-prone areas to continue	a. Plans and policies: – Flood inundation mapping – Appropriate planning policy including determining setbacks from rivers, reviewing building code, and regulating hazard zones – Appropriate design guidelines for critical infrastructure (roads, bridges, dams, buildings) – Emergency plans for supply disruption of water, electricity, and essential goods – Review and refine indigenous adaptation practices b. Protection strategies: – Awareness programmes on emergency flood management including early warning system – River training and protection works including at the upstream – Improved drainage system – Construction of flood retention ponds – Insurance of lives and properties against natural disasters c. Retreat: – Relocation of at-risk communities and infrastructure
Landslide	– Safeguard existing settlements and infrastructure from landslides – Restrict settlement	– Increase in the cases of torrential rains leading to landslides in hills – Significant loss of	– Increased cases of torrential rains to continue – Increased growth of settlements in	a. Plans and policies: – Mapping of landslide-prone areas (e.g., slope steeper than 30 degrees) – Appropriate land use planning and byelaws for new settlements including

Hazard	Objective	Current Situation	Futures Scenario	Adaptation Options
	growth on landslide-prone areas	lives and properties in hills every year – Loss of farmlands affecting livelihoods – Haphazard settlement growth in landslide-prone areas	landslide-prone areas to continue	determining setbacks from dangerous slopes and delineation of hazard zones – Appropriate design guidelines for critical infrastructure (roads, bridges, dams, buildings) – Emergency plans for supply disruption of water, electricity, and essential goods b. Protection strategies: – Awareness programmes on safety from landslides and mudslides – Slope stabilization programmes and construction of retaining walls and other protective structures – Improved drainage system – Insurance of lives and properties against natural disasters c. Retreat: – Relocation of at-risk communities and infrastructure
Glacial Lake Outburst Flood (GLOF)	Prevent GLOF and minimize damages from GLOFs	– Rapid melting of glaciers due to increased temperature leading to GLOF threats – Downstream settlements at risk	– Increase in the number of potentially dangerous glacial lakes	a. Plans and policies: – Hazard mapping – Analysis of hydrograph along the river channel downstream using proper simulation models to predict and understand damage in case of GLOF – Emergency plans for supply disruption of water, electricity, and essential goods b. Protection strategies: – Installation and operation of monitoring and early warning system at potentially dangerous lakes

Hazard	Objective	Current Situation	Futures Scenario	Adaptation Options
				– Regular extraction of water to a safe level – Construction of trapping dams with sufficient capacity to capture the debris and to dissipate the GLOF impact – Insurance of lives and properties against natural disasters c. Retreat: – Relocation of at-risk communities and infrastructure
Increased Temperature (leading to heat island effect)	Ensure safety of citizens from health problems related to heat strokes and safeguard infrastructure from extreme heat	– Steady rise in average temperature – Increase in built-up areas in cities – Drying-up of water sources and depletion of groundwater level – Cracks on roads leading to formation of potholes	– Increased 'heat island effect' in cities – Increased water insecurity – Distress migration to cities/towns due to droughts in rural areas – Increased energy use for cooling – Energy crisis due to high demand – Rising cases of people suffering from heat strokes – Decreasing level of service of infrastructure such as roads – Disruption of daily lives and economic	a. Plans and policies: – Health plans to address heat strokes and disease outbreaks – Water management plan – Land use plan to protect and promote urban green spaces and water bodies – Tree planting programme – Building code to support sun shades, building openings, and green roofs to reduce building temperatures – Building byelaws to restrict use of concrete or asphalt surface in open spaces b. Energy management strategies: – Energy demand management (domestic and business) – Reduction of energy and water consumption in new and existing homes, businesses and public buildings – Renewable energy generation – Incentives for green (energy efficient/ eco-friendly) buildings – Construction of climate-responsive

Hazard	Objective	Current Situation	Futures Scenario	Adaptation Options
			activities	buildings through the use of appropriate building materials, design, and construction technology c. Water management strategies: – Groundwater recharging – "Low regrets" infrastructure upgrades and repair (e.g., ground water recharge/impoundment areas) – Water conservation and awareness programme – Rainwater harvesting, groundwater recharge and improved infiltration – Minimization of system leaks and other water loss (e.g., surface reservoir evaporation) – Expanded or new reservoir capacity – "Low regrets" infrastructure upgrades and repair (e.g., reservoirs, water supply network) d. Infrastructure management strategies: – Construction of infrastructure resilient to adverse weather – Regular maintenance of infrastructure such as roads
Increased Rainfall (leading to urban floods)	Minimize disruption of daily lives and economic activities from heavy rainfalls	– Increased cases of urban floods in heavily built urban areas – Deterioration of roads (e.g., formation	– Increased cases of torrential rains to continue – Urban flooding to worsen due to increase in built-up	a. Plans and policies: – Land use plan to protect and promote urban green spaces and water bodies – Building byelaws to promote use of pervious materials in private open spaces to minimize surface runoff

Hazard	Objective	Current Situation	Futures Scenario	Adaptation Options
		of potholes) – Increase in vector borne diseases	areas	– Incentives to promote backyard gardening to minimize surface runoff – Promotion of rainwater harvesting at household level b. Protection strategies: – Improved drainage system – Construction of retention ponds – Early warning system
Cold Wave	Ensure safety of citizens from health problems related to cold waves	– Rising cases of cold waves particularly in Terai	– Increased energy uses for heating including increased consumption of fuelwoods – Increased cases of heating-related fire hazards – Energy crisis due to high demand – Rising cases of people suffering from cold waves – Disruption of daily lives and economic activities	a. Plans and policies: – Health plans to address cold waves – Emergency plans for supply disruption b. Energy management strategies: same as above

Source: Joshi (2017b) following UN-Habitat (2014) and, in the case of GLOF, Yamada (1998)

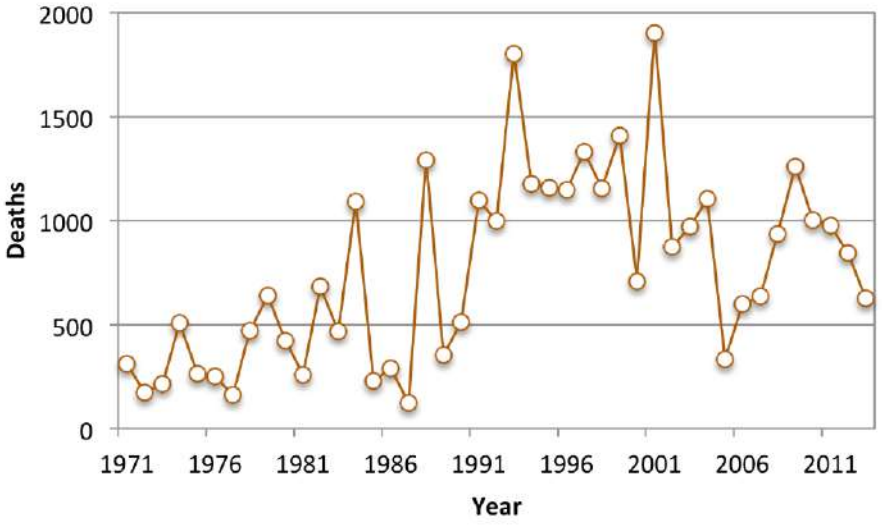
5.10.Climate Induced Disasters

5.10.1. Overview of Climate Induced Disaster

Nepal is one of the global "hot spots" for natural disasters in terms of high mortality risk from multiple hazards (Dilley et al., 2005). The hilly areas of Nepal are prone to landslides and Terai plains are prone to floods, while higher Himalaya and middle-mountains experience debris flow and glacial lake outburst floods (GLOFs). The middle-mountain and Teraiare affected by forest fires, and higher Himalaya by avalanche. The demographic factors such as rapid population growth, human encroachment into the vulnerable lands, poverty and widespread ignorance towards sustainable use of natural resources have further worsened the level of disasters risk. By ecological zones, hilly area is the most prone to disaster events (Aryal, 2012).

Records show that death due to disasters has increased during the period from 1971 to 2011 (Figure 5-16). Over the recent two decades, altogether 78 major events including floods and landslides, have occurred causing fatalities of 11,112 people with economic damage equivalent to USD 43 million (CFE-DMHA, 2012). During the last 100 years, water induced disasters were the most recurrent of the disaster types, and caused a significant economic damage.

Figure 5-14: Number of fatalities due to various disasters from 1971 to 2011 in Nepal



Source: DisInventer **(2018)**

5.10.2. Vulnerability and Impact Assessment

a. Glacier Lake Outburst Floods

In Nepal, GLOF events are common in the High-mountain areas, as there are large numbers of glacial lakes. Among the glacial lakes existing in Nepal, 32 are in high risk of outburst. The historical GLOF events in Nepal reportedly occurred about 450 years ago. Since then, 24 GLOFs have been reported in Nepal, out of which 14 were originating from Nepal Himalaya and the rest originating from the Tibetan part of China (Table 5-25).

Table 5-25: GLOF events recorded in Nepal

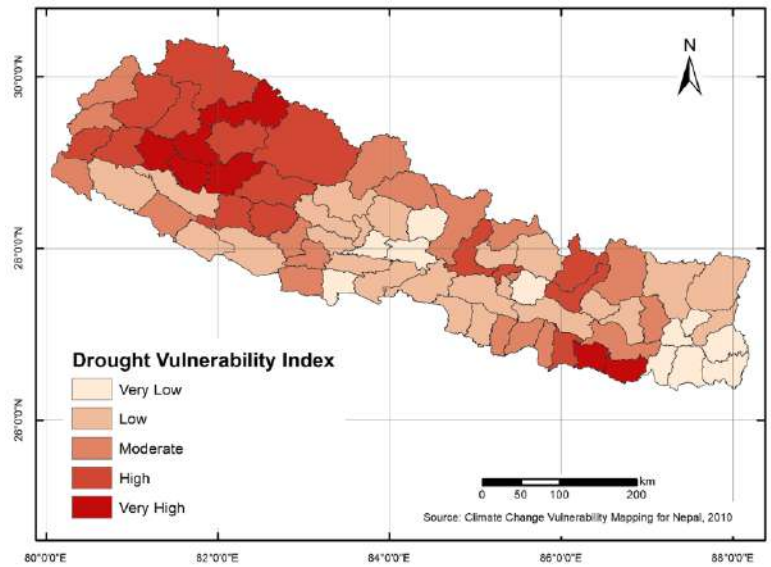
SN	Date	River basin	Lake
1	450 years ago	Seti Khola	Machhapuchhre
2	3 Sep, 1977	Dudh Koshi	Nare
3	23 Jun, 1980	Tamor	Nagma Pokhari
4	4 Aug, 1985	Dudh Koshi	Dig Tsho
5	12 Jul, 1991	Tama Koshi	Chubung
6	3 Sept, 1998	Dudh Koshi	Tam Pokhari
7	15 Aug, 2003	Madi River	Kabache Lake
8	8 Aug, 2004	Madi River	Kabache Lake
9	NA	Arun	Barun Khola
10	NA	Arun	Barun Khola
11	NA	Dudh Koshi	Chokarma Cho
12	NA	Kali Gandaki	Unnamed (Mustang)
13	NA	Kali Gandaki	Unnamed (Mustang)
14	NA	Mugu Karnali	Unnamed (Mugu Karnali)

Source: ICIMOD (2011a); NA= Not Available

b. Drought

In Nepal, the drought-like condition persists from the end of March till the monsoon arrives in June. However, in the Trans-Himalayan region (Manang & Mustang) are extremely dry throughout the year. The Terai and western hills are more frequently affected than other regions. About 5,000 families living in the Hills and Terai are badly affected by drought each year (MoHA & DP-NET, 2009). The drought of 1994 affected 35 districts of the country; crops over 157,628 hectares of land were destroyed. The lack of irrigation facilities makes the problem even worse, as prolonged drought conditions have adverse effects on crop production (Nepal Disaster Knowledge Network, 2014). Figure 5-17 presents the drought vulnerability for the districts of Nepal.

Figure 5-15: Drought vulnerability ranking of different districts in Nepal



Source: MoSTE (2014)

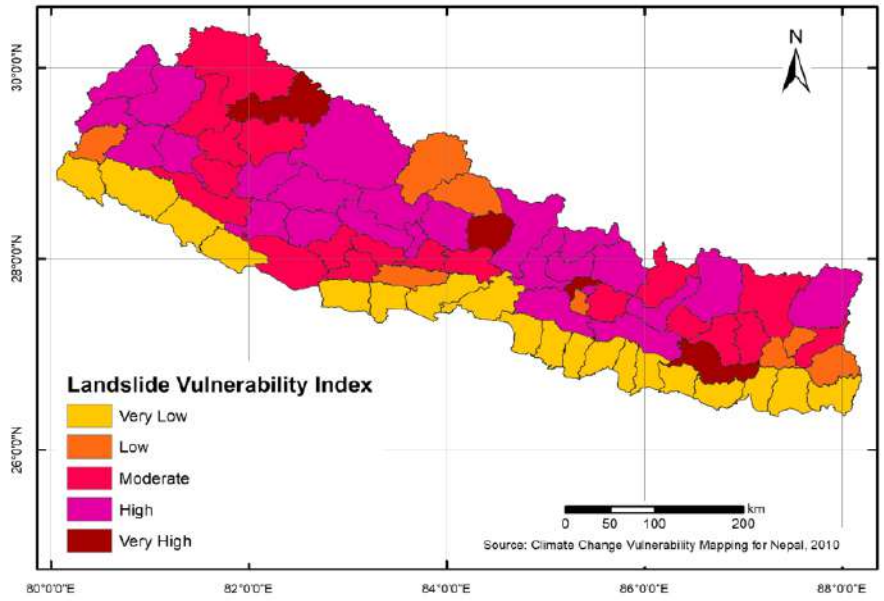
c. Water-induced Disasters

Water-induced disasters, such as flood and landslides, are very frequent in Nepal. Altogether 6,026 people lost their lives in floods and landslides between 1983 and 2001 and the economic loss was estimated to be NRs 11,860 million (MoPE, 2004).

Landslides

Landslides and floods are the most recurrent, intertwined and the most destructive hazards in terms of loss of lives and properties in Nepal (Figure 5-18). For instance, on August 5, 2014, mass landslides occurred in Sindhupalchok district blocking Sunkoshi River resulting in the loss of 156 lives, making the event the deadliest in three decades. The landslide also damaged part of the Arniko Highway disconnecting the capital city Kathmandu with the Tibetan capital Lhasa (Koirala, 2014). In 1993, a "mass movement" disaster (landslides combined with a flood) was, until then, the second most devastating natural disaster in Nepal after the 1934 earthquake. More than 2000 landslides triggered by cloudburst were along mountain slopes and highways. Around 1,170 people died and about 42,995 ha of arable land, roadways bridges and other infrastructures were damaged.

Figure 5-16: Landslide vulnerability ranking of different districts in Nepal



Source: MoSTE **(2014)**

Landslide Dam Outburst Floods (LDOFs)

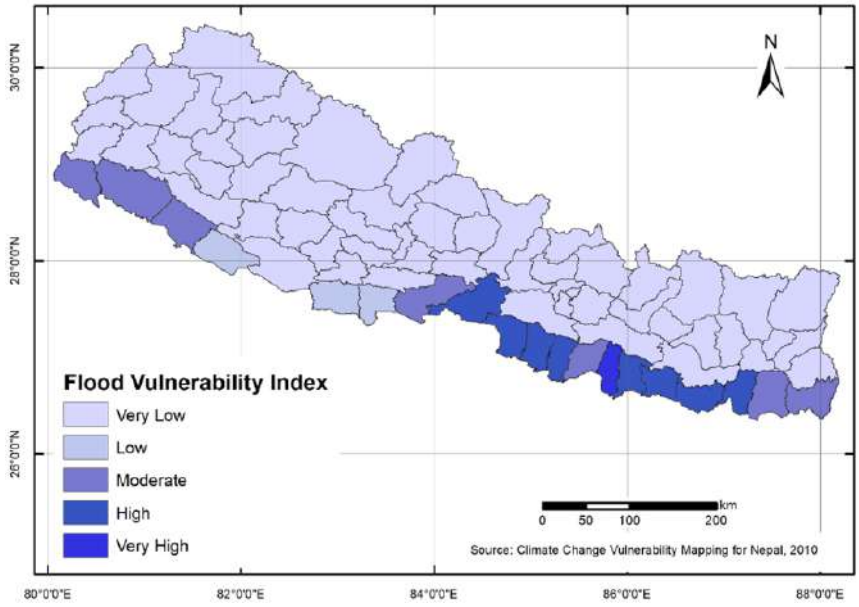
Eleven disastrous LDOFs have occurred between 1967 and 1989 (Khanal, 1996). The Budhi Gandaki river near Lukubesi (1968), the Sun-Koshi River near Barhabise (1982), the Balephi Khola in Sindhupalchok (1982) and the Gyangphedi Khola, Nuwakot (1986) were dammed by landslides. The resultant outburst floods took a heavy toll of human lives and infrastructure. An earlier example of this type of flash flood occurred in Larcha, Nepal in July 1996, taking away 22 houses and killing 54 people within few minutes. In early May 2012, flash flooding in the Kaski district of

north-western Nepal, near Pokhara, resulted in the death of at least 31 people, dozens missing, and caused great loss of property (ICIMOD, 2012). Landslide dam outburst events are generally random and cannot be predicted with any precision. Hazard assessment and identification of risky areas, a good communication system, and preparedness at local level are some essential measures for minimizing the LDOF risk.

Floods

The ranking of Nepal's districts in terms of flood vulnerability is shown in Figure 5-19. The floods triggered as a result of poor infrastructural design are also common in Nepal. Eight such floods have been reported. The failure of check dams and embankments in Butwal in 1981 led to loss of 41 lives, 120 houses and one bridge being swept away (ICIMOD, 2007). Similarly, in 1990, 26 people and 880 houses were swept away by a flood triggered by the failure of a check dam on the Rapti River in Chitwan. In 1993, the Bagmati River was dammed for a few hours due to blocking by tree logs at the Bagmati barrage; the ensuing outburst flood swept away 816 people in Rautahat and Sarlahi districts. The Larcha River was dammed by a boulder at the bridge over the highway in 1996; the subsequent outburst flood swept away 54 persons and damaged 22 houses (ICIMOD, 2007).

Figure 5-17: Flood vulnerability ranking of different districts in Nepal



Source: MoSTE **(2014)**

d. Windstorm, Thunderbolt, and Hailstorm

In Nepal, windstorm occurs mainly during the dry seasons between March and May. Thunderbolt occurs during monsoon and hailstorm takes place during the beginning and end of the monsoon. Hailstorm causes heavy losses of agricultural crops, but seldom affects human lives; whereas, windstorm and thunderbolt cause the loss of human life as well as properties. In 1999, windstorm and thunderbolt together killed 22 and injured 37 people. The disaster caused total loss of about NRs 7.2 million killing 50 cattle, destroying 85 houses and cattle-sheds and affecting 348 families.

During 2011, thunderbolt took the lives of 107 people in different parts of the country. In 2012, 56 people were killed in Udayapur, Sunsari, Saptari, Morang, Kaski, Jhapa, Dhanusha, Taplejung and Lamjung districts (Nepal Disaster Knowledge Network, 2014).

e. Cold-wave/Heat-wave

Terai region have been severely affected by the cold wave claiming the lives of a number of people and livestock each year. Most importantly, a cold wave gives rise to death and injury to livestock and human life. People, who do not have sufficient warm clothes and firewood for winter season, may suffer from cold wave. In January, February and December 2011, at least 65 people died due to the cold wave in Siraha, Mohattari, Rautahat, and Dhanusha districts. The GoN has endorsed the cold wave as a disaster event since 2011 (Nepal Disaster Knowledge Network, 2014). Heat waves that rise in atmosphere average temperature well above the average of a region have been reported to induce adverse effects on human population, crops, properties and services. This is common in Terai region in southern Nepal.

f. Fog/Drought

A study has reported that 3-month period drought associated with agriculture occurs evenly, whereas 12-month period drought associated with hydrology is consistent with 3-month drought for summer. Analysis of 33-year data shows that 9% of the area is covered with moderate drought, 5% with severe drought and 5% with extreme drought. Western and North-western regions have higher risks of short-term drought, whereas central and north-eastern regions possess risk of long-term drought. In case of drought related with El-Nino however, south-eastern region is under the higher risk (Sigdel & Ikeda, 2010).

g. Avalanche

The northern part of the country particularly the Higher-Himalaya is prone to avalanches because of thick snow cover on steep slopes. The avalanche of November 1995 took lives of 43 people including some foreign trekkers at Khumbu and Kanchanjunga areas. On 2 January 1999, 5 people were swept away by the avalanche that occurred in Gorkha district (Nepal Disaster Knowledge Network, 2014).

h. Extreme Events

Increased melt of snow and glaciers in Nepal Himalaya has resulted in formation of glacial lakes and expansion of existing ones in the mountain valleys (Ives et al, 2010). Higher temperature increases the likelihood of precipitation falling as rain rather than snow (IPCC, 2007b), which can result in increased likelihoods of floods during rainy season and decreased river flows during dry season. Chaulagain (2009) has revealed that decrease in snow cover areas exponentially increases the ratio of maximum-to-minimum stream-flows (i.e., increased maximum flows and decreased minimum flows simultaneously) in Nepalese rivers. Moreover, increased melting of snow and ice including permafrost can induce an erodible state in the mountain soil which was previously non-erodible. This has increased likelihoods of landslides in the mountains. Because of warming, snowmelt begins earlier and winter becomes shorter, which ultimately affects river regimes, natural hazards, water supplies, infrastructures and people's livelihoods (Jianchu et al., 2007).

5.10.3. Efforts to Reduce Vulnerability

The GoN has been putting its efforts to reduce vulnerability from the climate-induced disasters. The wider inter-ministerial coordination committee is formed to deal with the policy and institutional arrangements, whereas at the implementation level respective departments are engaged. To reduce the vulnerability from the climate-induced disasters, as mentioned in section 3.2.3, some efforts has been put in establishing the monitoring stations, the early warning systems, and even engineering works, like lake level lowering for the GLOFs risk reduction.

5.11.Gender and Social Inclusion

5.11.1. Overview of Gender and Social Inclusion

Vulnerability to climate change is context-specific and differs for each segment of society. It is influenced by a range of conditions varying from their degree of exposure and dependency upon weather patterns for livelihoods and adaptation capacities, which are influenced by gender, social status, economic poverty, power, access, and control and ownership over resources in the household, community and society (Nellemann et al., 2011). Vulnerability is not simply a consequence of natural hazards alone. Instead, it is related to one's resilience and capacity to cope with, or adapt to, the context of natural hazards, a process which is intricately connected to social structures such as gender, class, caste and ethnicity (Sugden et al., 2014; Regmi et al., 2016).

In Nepal, 'gendered' vulnerability to climate change relates to highly inequitable gender division of labour, as the workload of women is increased due to drying up of water spouts and diminishing forest resources. Notably, women are the primary caretakers of water and natural resources management. The other reason is that the women's control over income is more limited than that of men. Gendered vulnerability can also emerge from more complex processes such as male out-migration, which is often a primary response to climate stress on agriculture for the most marginal cultivators (Nellemann et al., 2014; Koirala et al., 2015). In the communities, women at home take double responsibilities and are still exposed to both risks (Nonoguchi, 2012). As such poor uneducated women particularly suffer from food shortage and financial burdens.

Men, women, boys and girls and socially excluded people are affected in different ways by policies, interventions and changing environments, based on their unique experiences, priorities, social norms and their relationships with nature and its ecosystem services. Their interaction with natural resources is not only supporting their livelihood but it may have also adverse impact to their day-to-day life if these resources are affected. Women have unequal access, control and ownership to these natural resources, and are often excluded from important decision and policy-making forums and institutions. Nepal's constitution has ensured 33% of seats for women representatives in its parliament and local bodies; however, their number is less than 10% in senior level positions in judiciary and administration (UNDP, 2010). Table 5-26 shows the increase of women percentage from 50.06% to 51.44% in a decade between 2001 and 2011 and similarly increased in households headed by female. Thanks to the increase in literacy percent among women from 34.9% to 57.4% that may help cope up with new burdens including those posed by climate change recently.

Table 5-26: Demographic Statistics of Gender (%)

Year	2001		2011	
Indicator	Women	Men	Women	Men
Population	50.06	49.94	51.44	48.56
Literacy	34.9	62.7	57.4	75.1
Female Headed Households	14.87	85.13	25.75	74.25

Source: Nepal Living Standard Survey (2010/2011) retrieved from Gurung & Bisht (2014)

Women headed households and those with limited access to modern agricultural input, infrastructure and education are more sensitive to impacts of extreme events on food security. It is therefore important to identify specific vulnerabilities, risk and impacts of climate change on women and marginalized groups in order to help designing gender and social inclusion responsive adaptation plans and strategies for specific thematic sectors. In the aftermath of flooding, cases of water-borne diseases are significantly higher. Apart from facing a personal security issue, women are endowed with the responsibility of providing resources for themselves and their families (Alam, 2015). Recognizing the differentiated roles that women and men play as natural resource managers and food providers, there is a necessity of engaging women and men in early warning systems and disaster preparedness programmes (Shrestha et al., 2014).

Key livelihood dependent sectors are agriculture, forest, biodiversity, tourism and hydropower. Water resources are more exposed due to unpredictable weather patterns and extreme weather events. Similarly, communities whose livelihoods depend on forest-based products are exposed to the impacts of climate change due to pests, disease attacks, changes in rainfall pattern and rising temperatures leading to forest fires and forest degradation. Extreme climate events can wash away essential infrastructure like roads, bridges, houses, schools and public buildings that directly impact the lives of poor and marginalized people living in isolated and remote areas (MoPE, 2017a).

According to the 2011 census, the indigenous nationalities (Adivasi Janajati) of Nepal comprise 36% of the nation's total population. This population embrace over 100 castes and ethnic groups including 15 Dalit castes. Although the laws have banned untouchability and affirmed the rights of all citizens, irrespective of caste or gender, to equal treatment, discrimination based on caste persists. Because the Dalits are socially excluded, they have no access to potable water and compromise with the polluted water which may worsen in the wake of climate change. The incidence of poverty is higher among ethnic minorities such as the Tharu and Mushahar, and tribal groups such as the Chepang and Raute than for the population as a whole (ADB, 2002). As poverty and food insecurity are closely related, these people have high food insecurity.

5.11.2. Vulnerability and Impacts of Climate Change on Gender and Social Inclusion

a. Vulnerability

Poor, marginalized and landless farmers practicing subsistence agriculture are more exposed to the adverse impact of climate change such as floods, cold waves and heat waves. About 90% of crop loss in Nepal is caused by weather or meteorological events (UNDP, 2009). Tribal and members of lower caste groups are also particularly vulnerable to food insecurity, they have large food production deficits. In addition to differences in food insecurity between agro-ecological zones, there are also differences and inequalities along the east to west gradient. In general, marginal farm

households in western districts are more vulnerable than similar households in central and eastern districts of the country (FAO, 2004).

Besides agriculture, the anticipated losses resulting from increased intensities of weather-related hazards, epidemics and diseases are likely to add to the sufferings of the population with overall damage to the national infrastructure (Sharma, 2009). The Climate Induced Disasters Thematic Working Groups (TWGs) suggests that women, and poor and marginalized groups are more vulnerable to climate-induced disasters since they have lesser access to early warning systems and fewer survival skills. Moreover, in post disaster temporary settlements women are vulnerable to sexual violence. They are excluded from disaster recovery decision-making in policies and programmes. In addition, food scarcity after the disasters leaves women with fewer options for food, and they often eat less causing negative impacts on their health (Mainlay & Tan, 2012).

b. Impacts

Shifts in the monsoon season, longer dry periods and decreased snowfall push poor and marginalized community more vulnerable. Floods and droughts adversely affect agricultural production and productivity resulting in income shortages. Increasing need for livelihood diversification triggers outmigration (predominantly men, with 12% women migrant workers). The primary responsibility for agricultural and household work falls on women (Leduc, 2009; ICIMOD, 2011b), resulting not only in increased drudgery, but also increased decision-making power, as women being key natural resource managers at the household level (Nellemann et al., 2011). Outbreaks of pests and diseases in crops and livestock are increasing, with devastating crop and biodiversity loss posing a direct threat to the livelihoods of poor and marginalized people (Leduc, 2009).

The marginalized or indigenous groups, particularly Majhi, Raute, Chepang, Satar, are more vulnerable to food insecurity due to disasters like floods, landslides and fire. Indigenous people have traditional knowledge, skill and practice in production, seed preservation and other related activities. Regarding forest and biodiversity issues, among the poor and marginalized people, women are highly responsible to manage the household need like fuel wood and fodder for livestock. Climate change vulnerability impacts on forestry seem additional burden in household activities for women because of their social and cultural roles and responsibilities towards families and communities. Women often have to bear physical risks to collect fuel wood and fodder as they have to walk a long distance. Regarding water and energy sector, women are primarily responsible for water use (cooking, health and hygiene, kitchen garden and livestock etc.). So, they have to walk long distances to collect water and fuel, exposing women and girls to harassment or sexual assault.

5.11.3. Adaptation measures to reduce vulnerability

Recognizing the reality and differences in the case of gender and social inclusion part, the GoN aims to promote inclusive development by ensuring participation, access to opportunities and sharing of benefits across all individuals and groups. The goal of climate adaptation and equitable development can only be achieved if a fair share of benefits is distributed among all fraction of society, irrespective of their caste, class, ethnicity, gender, age and disability status (NAP, 2017). Livelihood based social protection integrating the climate change adaptation and disaster risk reduction is crucial for sustainable societies (Sharma, 2011).

Nepal has developed policies plans, programmes and mechanisms for addressing climate change (National Climate Change Policy 2019, NAPA, LAPAs,) where women's differentiated impacts, capacities and larger engagement are acknowledged. Nepal's Human Development is almost one third lower than it could be if it were more equally distributed and by 2050 the South Asia Human Development Index (HDI) would be 12% lower than the baseline in an "environmentally challenged scenario" and globally 15% lower in more adverse "environmental disaster scenario" (HDR, 2011; adopted from IDS-Nepal, PAC and GCAP, 2014).

Nepal adopted the Forest Sector Gender and Social Inclusion Strategy (MoFSC, 2007) to address gender and social inclusion issues. The strategy has identified the following four change areas in order to attain the institutional vision: (i) gender and equity sensitive policy and strategy, (ii) equitable governance, (iii) gender and equity sensitive organizational development and programming, and (iv) equitable access to resources and benefits. Accordingly, Community Forest User Committees are required to have representation of women, Dalits and members of indigenous community in required proportions. The National Climate Change Policy (2019) has provision for women's participation in the implementation of climate adaptation programmes. The policy calls for ensuring the participation of poor people, Dalits, marginalized indigenous communities, women, children and youth in the implementation of climate adaptation and climate change related programmes. Different ministries have dedicated sections to ensure gender equality and social inclusion in the implementation of relevant policies and programmes.
Non-government agencies also have gender and social inclusion policies and institutional arrangements.

Studies suggest the need for following measures (MoPE 2017a; MoFSC 2017; Mainlay & Tan, 2012):

- Produce disaggregated data to describe men's and women's differing livelihoods strategies, circumstances and opportunities. This information is crucial to measure and to properly understand the gendered effects of projects to address climate change vulnerability.
- Carry out detailed and context specific research on the differential impacts of climate change on women and men in Nepal and to enhance awareness and capacity building programmes.
- Improve coordinated and integrated efforts for formulating adaptation plans and strategies at different levels and sectors.
- Empower women by reducing women's vulnerability with provision of skills and capacity through gender focused service delivery mechanism.

5.12.Laws, Policies, Plans and Activities

To streamline effort on addressing climate change, Nepal has adopted policy, legal and programmatic measures. The MoFE is the focal ministry to climate change and has been mandated to formulate plans and policies on climate change, forests, and environment. It endorsed National Adaptation Programme of Action (NAPA) in 2010 and Climate Change Policy in 2011, which was replaced by National Climate Change Policy in 2019. It adopted Environment Protection Act in 2019, with specific provisions on climate change management. It introduced National Framework on LAPA in 2011, which has been updated in 2019. Nepal is currently in the process of development of National Adaptation Plan (NAP) and undertaking vulnerability risk assessment.

The GoN has adopted whole-of-government approach to managing climate change. To do this, CCMD has been created under MoFE to serve as the focal point for coordinating government effort as well as for coordinating with the national and international organizations. A highlight of the policies and legal measures adopted in Nepal is presented in Table 5-27. The sections that follow discuss the following initiatives and interventions that have been undertaken over the past decade:

- Legal measures, including the constitutional provisions, and forest laws and regulations, environmental laws, and local governance related laws
- Policies related to climate change – including those exclusively focusing on climate change and sectoral policies that attend to climate change issues
- Plans and Programmes
- Strategic Frameworks
- Activities

5.12.1. Legal Provisions

Constitution of Nepal (2015)

The Constitution of Nepal has defined healthy and clean environment as the fundamental right of the citizen (Article 30). The directive principles include policies regarding conservation, management and use of natural resources. In annexes of the constitution, schedule 5, 6, 7, 8 and 9 provide list of the roles, responsibilities and coordination mechanisms. The municipalities shall make rules required under its defined domains or jurisdictions to operate the given responsibilities and regulate procedures, while complying with provincial and national laws.

Local Government Operation Act (2017)

The Government Operation Act 2017 came into effect in October 2017. It has paved a legal foundation towards institutionalizing legislative, executive and quasi-judiciary practice of the local governments (municipalities). It clarifies the rights of the municipalities to formulate local laws, rules and regulations and criteria for environmental conservation, control pollution and manage solid wastes. It also authorizes the local government in implementing climate change mainstreaming into local plans, including GESI, and building institutional capacities through making operational guidelines, procedures and criteria.

Environment Protection Act (2019), Environment Protection Regulation (2020)

The Environment Protection Act (EPA, 2019) makes legal provisions in order to maintain clean and healthy environment by minimizing, as far as possible, adverse impacts likely to be caused from environmental degradation on human beings, wildlife, plants, nature and physical objects. It also defines the provisions of Environment Impact Assessment (EIA) and Initial Environment Examination (IEE) while implementing development projects. The GoN has released the EPR 2020 to implement the EPA (2019).

Table 5-27: Climate change related policies with its responses, potential impact areas and level of governance

Policies/Plans and Regulations	Response		Potential impact areas				Level of Governance		
	Mitigation	Adaptation	Agriculture	Water	Forest	Disaster	Federal	Provincial	Local
Regulatory Frameworks									
Water Resource Act, 1992			*	*	*	*	*		*
Forest Act, 2019					*	*	*		*
Environment Protection Act, 2019 and its Regulations 2020				*	*	*	*		*
Local Government Operation Act (LGOA), 2017	*	*	*	*	*	*	*	*	*
Disaster Risk Reduction and Management Act, 2017	*	*				*	*	*	*
Policies/plans and Strategies									
National Conservation Strategy (NCS) 1998	*	*	*	*	*		*		
Nepal Biodiversity Strategy, 2002	*	*				*	*		
National Water Resources Strategy, 2002	*	*							
National Agriculture Policy, 2004	*	*	*	*	*		*		
National Water Plan (2005)	*	*		*		*	*		
Water Induced Disaster Management Policy, 2006	*	*		*		*	*		
Three Year Interim Plan (2007/08-2009/10)	*	*				*	*		
National Strategy for Disaster Risk Management in Nepal (2009)	*	*				*	*		
National Adaptation Programme of Action (NAPA), 2010		*	*	*	*	*	*		
National Climate Change Policy, 2019	*	*	*	*	*	*	*	*	*

Policies/Plans and Regulations	Response		Potential impact areas				Level of Governance		
	Mitigation	Adaptation	Agriculture	Water	Forest	Disaster	Federal	Provincial	Local
Local Adaptation Plan for Action (LAPA) 2011		*	*	*	*	*	*		*
Climate Resilient Planning Tool, 2011	*	*	*	*	*	*	*		
Climate Change Adaptation and DRM in Agriculture: Priority Framework for Action 2011–2020		*	*				*		
Local DRM Planning Guidelines, 2012		*				*			*
Thirteenth Plan (2013/14-2015/16)	*	*	*	*	*	*			
Irrigation Policy, 2014		*	*	*	*	*	*		
Water Induced Disaster Management Policy, 2015		*				*	*		
Forest Policy, 2019	*	*				*	*		
National Adaptation Plans (NAPs) 2015		*	*	*	*	*	*		
National Land Use Policy, 2015	*		*		*		*		
Agriculture Development Strategy (2015-2035)		*	*				*		
Fourteenth Periodic Plan (2016/17-2018/19)	*	*	*	*	*	*	*		
Forestry Sector Strategy (FSS), (2016-2025)	*	*	*	*	*	*	*		
National REDD+ Strategy	*	*				*	*		
National Ramsar Strategy and Action Plan, Nepal	*	*		*	*		*	*	*
National Agroforestry Policy	*	*	*	*	*	*	*	*	*

5.12.2. Policies

National Climate Change Policy (2019)

The Climate Change Policy (2019) aims at contributing to socio-economic prosperity by developing climate resilient society. The GoN released a new climate change policy by repealing the Climate Change Policy of 2011. The 2019 policy has the objectives of advancing capacity on CCA, developing ecosystem resilience, promoting green economy by adopting low carbon economic development concept, mobilising national and international financial resources, making effective the information service, mainstreaming climate change into relevant policy, strategy, plan and programmes, and also mainstreaming gender and social inclusion, including in climate change mitigation and adaptation programmes. The policy has 8 thematic areas and 4 cross-cutting areas.

Renewable Energy Subsidy Policy (2016)

The Renewable Energy Subsidy Policy (2016) aims to reduce the dependence on traditional and imported energy by increasing access to renewable energy to improve the livelihoods of local people and create employment activities. The policy provides an overview of the specific subsidies and conditions provided, depending on technology, region and local context.

National Agriculture Policy (2004)

The National Agriculture Policy (2004) is designed to address the needs of both farmers with access to resources and farmers with comparatively less access and opportunities to address issues of agricultural production and productivity. It has mentioned interventions targeted to farmers with less than half a hectare of land without irrigation and farmers belonging to Dalit and other marginalized groups. Other areas of promotion include commercial farming, conservation, promotion and utilization of natural resources and the environment and establishing a monitoring and assessment system.

Forestry Sector Policies and Strategies

There are at least five policies in forestry sector which have considered/included provisions on climate change. They are National Forest Policy (2019), Forest Act (2019), Forestry Sector Strategy (2016- 2025), Nepal Biodiversity Strategy and Action Plan (2014-2020) and Community Forestry Development Guideline (Third Revision, 2014).

National Forest Policy (2019) was formulated with a long-term vision of contributing to local and national prosperity through the management of forests, conservation areas, watersheds, biodiversity, flora and fauna in sustainable and participatory approach and improving the generation of forest products. Adaptation to and mitigation of adverse impacts of climate change is one among the seven major themes of this policy. It emphasizes both the adaptation and mitigation through community-based forest management. It aims to implement Reducing Emission from Deforestation and Forest Degradation (REDD+) programme to enhance carbon stock in the forests.

Nepal prepared Forestry Sector Strategy (2016-2025) with the vision of sustainable management of forest ecosystems and optimization of biodiversity and watersheds for national prosperity. One of the goals of the Strategy is to make forest resources climate resilient. There are five expected outcomes to achieve through the goal stated in the FSS, and one of them is “climate resilient capacity of society and forest ecosystems enhanced”.

A party to the convention on biological diversity (CBD) since 1992, Nepal has prepared Biodiversity Strategy and Action Plan (2014-2020). One of the cross sectoral themes of the NBSAP is adaptation and mitigation to address the impacts of climate change. Two identified strategies under this theme are: Adaptation to and mitigation of the impacts of climate change on biodiversity, and Enhancing the resilience of ecosystems, species and human communities to the climate change impacts.

Promulgated in 2019, the Forest Act addresses the contemporary forestry issues in changing context. It has included provisions on climate change adaptation and also illustrated the importance of climate change adaptation activities in community forestry and that the CFUGs can prepare the community adaptation plans.

Energy Policy and Environment-Friendly Vehicle and Transport Policy

In context to the climate change, two more policies are relevant; viz. Energy Policy and Environment-Friendly Vehicle and Transport Policy. The Energy Policy highlights the maximum utilization of hydropower potential to meet its domestic demand of electricity by mitigating adverse environmental impacts and accelerate renewable energy services, and increase access to the Renewable Energy technologies with subsidy provisions. Environment-Friendly Vehicle and Transport Policy aims to reduce emission from transport sector, increase the share of electric vehicle up to 20% by 2020, promote the transformation of other regular vehicle to electric vehicle, and provide subsidy scheme for the promotion of electric and non-motorized vehicles.

5.12.3. Plan and programmes

National Adaptation Programme of Action (NAPA)

NAPA is the first comprehensive government response to climate change (MoE, 2010). It has identified nine urgent and immediate climate change adaptation priority programmes related to six thematic sectors (agriculture, forest biodiversity, water resources, health, infrastructure, and disaster). NAPA also specified a coordination mechanism and implementation modality for climate change adaptation programmes.

Local Adaptation Plan of Action (LAPA)

LAPA complemented national-scale adaptation activities or programs to address location-specific adaptation needs. LAPAs were developed in different local governments through Nepal Climate Change Support Programme (NCCSP). This programme was the first significant government-led initiative on community-based adaptation through integrated management of agriculture, water, forest and biodiversity sectors.

National Adaptation Plan (NAP)

In 2015, the GoN initiated the process of National Adaptation Plan (NAP) engaging seven TWGs and two Cross-cutting Working Groups (CWGs), which covered the major climate change sensitive sectors. NAP aims to reduce vulnerability to the impacts of climate change by building adaptive capacity and resilience; and integrate of climate change adaptation into existing policies/plans and programs within all relevant sectors and at different levels (MoPE, 2017b). It also worked to develop a common understanding on the 'Vulnerability and Risk Assessment (VRA)' methodological framework and tools for Nepal's NAP formulation process. It has proposed a framework for

vulnerability and risk assessment (VRA) using IPCC-AR5 as the foundation. The IPCC framework considers risk as a function of hazard, exposure, and vulnerability. The proposed framework unpacks the elements of risk and customizes them to needs and applicability in the national context. The framework assumes that the risk of climate related impacts results from the interaction of climate-related hazards (including hazardous events and trends) with the exposure and vulnerability of human and natural systems. Changes in the climate system (trends and scenarios), biophysical system, and socioeconomic processes (including governance and adaptation and mitigation actions) are drivers of hazards, exposure, and vulnerability.

5.12.4. Strategies and Frameworks

Followings are the major highlights of the strategies and frameworks:

National REDD+ Strategy (2018-2025)

- Initiatives to further contribute to promoting sustainable management of forests, carbon sequestration and adaptation co-benefits.
- Envisioned to optimize carbon and non-carbon benefits of forest ecosystems for the prosperity of the Nepali people, and has objectives of, inter alia, reducing carbon emission, and enhancing carbon sequestration and climate resilience.

Agriculture Development Strategy (2015-2035)

- Sets forth priorities to move toward self- reliant, sustainable, competitive, and inclusive agriculture sector that drives economic growth and contributes to improving livelihood, food and nutrition security leading to food sovereignty
- Includes strategies for poverty reduction, agricultural trade competitiveness, and establishing higher and more equitable income and rights for farmers
- Includes various measures targeted at the most disadvantaged rural population including poor households, women, indigenous peoples, Dalits and other marginalized communities, especially with a focus on improved food security.

Nepal's Second Nationally Determined Contributions (2020)

- Provides CO2 emission reduction quantitative and policy targets in four sectors namely, Energy, IPPU, AFOLU and Waste.
- Prioritizes climate-resilient sustainable land and forest management, ecosystem rehabilitation and restoration, strengthening community-based NRM, and improving agricultural techniques
- Adaptation priorities and actions, as per the National Climate Change Policy 2019, adopt an integrated approach to cover climate sensitive sectors exemplifying the inter-sectoral nature of the responses covering eight thematic and four cross-cutting areas.

Water Resource Strategy (2002)

- Recognizes the connection between human activities, natural factors, and risks of severe flooding and environmental deterioration, economic loss, and displacement of people and that this calls for improved holistic watershed management
- Provides roadmap to strengthen institutional capacities, implement watershed and aquatic ecosystem programmes, and meet long-term requirements for social and ecological sustainability.

Climate Change Adaptation and DRM in Agriculture Priority Framework for Action (2011-2020)

- Addresses five priority action areas: (i) institutional and technical capacity for climate change adaptation and disaster risk management in agriculture, (ii) assessment and monitoring of climate risks, vulnerabilities and enhancing early warning systems, (iii) improving knowledge management, awareness raising and education on climate change, adaptation and disaster risk management, (iv) reducing climate related risks and underlying vulnerabilities by implementing technical interventions in agriculture and livestock, (v) strengthening capacities and procedures for effective disaster preparedness, response and rehabilitation
- Identifies gaps in existing plans and strategies and provides a list of actions relevant to climate change adaption, NAPA and national strategies for disaster risk management.

Environment-friendly Local Government Framework (2013)

- Aims to establish environmental governance and create a sustainable environment-friendly society at multiple levels from the household to village to municipality to district
- Contributes to mainstreaming environment, climate adaptation and disaster management issues into local planning and encourages the coordination and cooperation between environment and development
- Increases local ownership and recognizes the leadership roles of local institutions and the importance of positive competition for motivating environmental management.

Nepal Country Report on Sustainable Development Goals 2016-2030

- Gives update on Nepal's status on reaching the SDG targets
- Provides breakdown of GHG emissions, including in relation to agriculture sector, and the projected changes expected until 2030.

5.12.5. Activities

A. Ratification of the Paris Agreement

The Paris Agreement on Climate Change that was adopted in Paris in December 2015 and signed by leaders from 177 countries in New York during the high-level Signature ceremony will enter into force 30 days after ratification by at least 55 countries and by countries representing at least 55% of global emissions. Even though, Nepal's emission is negligible, its ratification will show positive signal and helps to contribute in reaching minimum countries requirement (at least 55 countries). The representative of Nepal in the High-Level Signature Ceremony of the Paris Agreement has stated, "Nepal intends to submit the instrument of ratification at the earliest".

B. National Framework on LAPA (2011)

Realizing the climate change as a major agenda, the GoN has approved the national framework on LAPA to address the internalize and prioritize the climate change adaptation action from local level to national level. The framework provides a way to integrate the specific needs of local people for climate change adaptation and resilience into local-to-national level planning. It also helps ensure that the process of integrating climate change resilience into planning is a bottom-up, inclusive, responsive and flexible process. As the goal set out initially in Nepal's Climate Change Policy (2011) to improve the people's livelihoods through climate change impact mitigation and adaptation activities of the GoN in implementing the policy and the NAPA, and to support other initiatives,

including coordination mechanism as well as delivering climate adaptation results at the local level. NAPA has identified and prioritized the adaptation options, and implemented "Increasing community-based adaptation through integrated management of agriculture, water, forests and biodiversity" in the name of NCCSP.

UK Aid and European Union are the funding organizations with a total contribution of 14.6 million pound. Approximately 80% of the fund allocated for the implementation by the government is being used for local level activities. The remaining 20% is allocated for institutional capacity building and coordination at the national level. The 100 LAPAs developed by the local communities at VDC level are being implemented. The goal of the NCCSP is to contribute towards enhancing the adaptation capacity of the poorest and most vulnerable communities in Nepal. The programme has a key objective to enhance capacity of the Government, particularly, MoPE and MoFALD and non-governmental (NGOs, CBOs, private Sector and Communities) institutions to implement the former Climate Change Policy (2011) and most urgent and immediate adaptation actions to increase the resilience of the climate vulnerable poor people.

Through NCCSP, the LAPAs are being implemented in 14 districts: Achham, Bajura, Kailali in the Far Western region and Bardiya, Dolpa, Humla, Jumla, Mugu, Dailekh, Jajarkot, Kalikot, Dang, Rolpa and Rukum in the mid-western region. The target area has an approximate population of three million. The primary beneficiaries of the programme are the poorest and most climate vulnerable people, particularly poor women and men from disadvantaged and marginalized groups. Other stakeholders include the district line agencies, community-based organizations, non-government organizations, indigenous, groups, MoSTE, the Climate Change Council, Ministry of Finance, MoFALD.

C. Promoting Ecosystem-Based Adaptation (EbA)

The EbA concept was introduced and the term coined at the UNFCCC COP14 in Poznan in 2008. Since then, the concept has successfully been promoted into broader negotiations, policies, strategies and action plans. EbA has been suggested as an appropriate adaptation effort to minimize climate risks to society, economy and ecosystems. In Nepal, the government line agencies are implementing the EbA programmes in partnership with national and international organizations such as IUCN, UNEP, UNDP, and TMI. Academic institutions and research NGOs are taking part in generating EbA knowledge. In 2013, Nepal undertook the first pilot project of mountain EbA in Panchase covering three districts Syangja, Kaski, and Parbat. Alongside the Panchase, EbA South project was implemented covering central part of Nepal. In further impetus, the programme of "Scaling Up Mountain EbA Building Evidence, Replicating Success and Informing Policy" was taken up in 2017. At present, an urban EbA project focusing in Kathmandu valley is in progress.

D. Second Nationally-Determined Contributions (NDC)

The GoN prepared and communicated its Second Nationally Determined Contributions (NDC) to the UNFCCC Secretariat in December 2020, which realizes the importance of reducing the impact of climate change and seeks to implement emission mitigation and climate adaptation actions. Recent NDC has set both quantitative and policy targets to mitigate the GHG emission envisaging the pathways to net zero emission by 2050. Similarly, the NDC has also set adaptation priorities and actions to the eight thematic and four cross-cutting areas as indicated by Climate Change Policy (2019) of Nepal.

5.13. Adaptation Action Plans

On the basis of vulnerability and impact assessment for different thematic sectors, Adaptation Action Plans for all of them have been prepared in this TNC. The plans are based on the policies and programme-budget of the Federal as well as Provincial Governments. Consultation meetings were held with officials at Federal and Provincial levels to discuss vulnerability and adaptation priorities.

The action plan includes the objectives, proposed actions, monitoring and assessment indicators, time frame and budget for implementation, and implementing/responsible entities for each sector. Time frame is divided into short (<5 years), medium (<10 years) and long term (>15 years). Similarly, budget size of actions is also categorized into small (USD < 1 million), medium (USD <9 million) and large scale (USD >10 million).

Annex 2 of this TNC presents Adaptation Action Plans for the sectors.

6. CONSTRAINTS AND GAPS, AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS

6.1. Introduction

While preparing this Third National Communication (TNC), the Government of Nepal (GoN) faced a number of constraints and gaps. This chapter reports on these "constraints and gaps, and related financial, technical and capacity needs of Nepal".

These constraints and gaps represent the limitations of the TNC and of the actions suggested or planned herein. The TNC, both as process and output, provides an important opportunity for a comprehensive stocktaking of climate-change-relevant data at the national and subnational levels.

6.2. Key Gaps in the Third National Communication

6.2.1. Data Quality and Uncertainty in GHG Inventory

Maintaining the quality of technical processes and resulting data in GHG inventory is pivotal for this TNC. However, in most cases maintaining data quality has become a challenging task because of unavailability of reliable and disaggregated national data. Almost all the data used while preparing the TNC are based on secondary data sources (Tier 1 level data). Although data quality was given high priority, there is still the possibility of data inconsistency and inaccuracy due to the lack of human and financial resources both with the data sources and the compilation team. Quality assurance is another important aspect of TNC process. Still, it was not thoroughly undertaken.

Similarly, in accordance with IPCC guidelines, the GHG inventory preparation process is expected to ensure sufficient activity data collection, choice and development of methods, emission factors and other parameters. But Nepal does not have its own country specific emission factors for almost all the key categories except for livestock enteric fermentation. Accordingly, the calculations are based on regional information. Several uncertainties have been detected in National GHG Inventory, one of which was the poor data quality due to the use of Tier 1 data and emission estimate. These uncertainties are due to the degree of accuracy of the activity data and emission factors. Similarly, there was limited information to evaluate the accuracy of the activity data used in each category of energy sector. Further, there is lack of inventory QA/QC plan in accordance with the 2006 IPCC Guidelines.

Nepal needs to enhances the database, archiving system and work for development of country-specific emission factors, and QA/QC and uncertainty analysis.

6.2.2. Technology Gaps in Adaptation and Mitigation

Technological gaps comprise an important bottleneck in Nepal's efforts at mitigation and adaptation to climate change. Indeed, over the years the lack of appropriate technology and financial resources has seriously impeded Nepal's ability to implement adaptation and mitigation options. Adaptive and mitigation capacity is likely to vary, depending on availability and access to

technology at various levels- from local to national and in all sectors. Many of the adaptive strategies identified as feasible in the management of climate change directly or indirectly involve technology, such as warning systems, protective structures, crop breeding and irrigation, settlement and relocation or redesigning flood control measures, improved irrigation techniques to cope with drought, and new plant varieties which are resistant to drought or to flood, etc.

Similarly, mitigation technologies include use of energy efficient vehicles and equipment, use of alternative energies, short rotation forestry, methane recovery from organic waste etc. Some of these technologies are in continuous process of development. Recognizing the country's resource constraints and economic status, the mitigation options need to be recommended based on the cost-benefit analysis and multi-criteria analysis. Side by side, Barriers, including institutional framework and monitoring and evaluation issues need to be addressed in the implementation programme and strategy.

6.2.3. Constraints and Gaps in Research, Systematic Observation and Networking

Department of Hydrology and Meteorology (DHM) is only institution responsible for collection and production of information related to climate change and weather events. The current data collection is inadequate because of poor spatial coverage of metrological stations as well as quality of data being captured. Stations measuring air temperature and precipitation are well distributed in lower altitude regions of the country. However, at higher altitude regions, the number of stations decreases rapidly, which results in immense limitation in understanding the climate of Nepal. Similarly, projections of climate under different scenarios, general circulation models (GCMs) are realistic and generally applied. However, due to poor spatial resolution, the models that are currently adopted by DHM unable to capture climatic details forced by local topographical variations. Hence, downscaling of the GCM products is required. A new robust stations network and dissemination system will be deemed necessary if the system is expanded from its current capacity. The other areas of interventions that need to be undertaken are:

- Review of climate change scenarios for Nepal applying the best performing model;
- Analysis of the available meteorological data records during the last several decades to identify trends in temperature, precipitation, solar radiation, wind and others.
- Analysis of climate extreme events;
- Assessment of the impacts of climate change on snow and glaciers and mountain ecosystem with special emphasis on potential GLOF hazards and their impacts.

6.2.4. Constraints, Gaps and Financial needs in Technology and Capacity Development

Nepal is in the process of identifying its technological needs in the context of climate change. However, the public policies and strategies have not fully geared towards taking the opportunities associated with technology transfer for climate change adaptation and mitigation, and the level of awareness and technological knowhow is also low. Given this, there are gaps in capacity building which can be addressed through further investment in technology and capacity development. Nepal, with great potential of renewable energy (hydropower, and biomass), is in distinct position to adopt a low-carbon emission path for its economic development. This requires sufficient technical human resource and adequate financial resources.

Nepal needs a national-level programme and implementation strategy for refining technology needs and evaluating technological options. It also needs to evaluate the linkages and contribution of these technologies to cost-effective adaptation and abatement within the national development goals and to identify modalities or financial mechanisms for technology transfer. At the same time, training of key personnel to implement climate friendly technologies is also necessary.

6.2.5. Legal and institutional constraints and Gaps

There are legal and institutional gaps while preparing TNC. There is insufficient coordination among government institutions regarding climate change and GHGs data sharing, integration, and management. In addition, enough legal and institutional arrangement has not been set up to coordinate among national and provincial government institutions on data collection and reporting. These comprise key challenge to comply with transparency provisions and reporting requirements under the UNFCCC.

The other legal and institutional constraints and barriers are:

- Legal and policy enforcement and planning of climate change actions
- Uncertainties related to research on climate change projections, its potential impacts, and consequences of the implementation of climate change response actions
- Mainstreaming and integration of climate change issues into national, subnational, and sectoral development programmes and plans
- Coordination among the government ministries and agencies, as well as among the international financing and project implementing entities.

6.3. Gaps and Constraints in TNC Preparation activities

One of the key challenges Nepal faced during the TNC is the establishment and strengthening of inter-ministerial coordination mechanisms. Climate change is still new as a political agenda, and the mandate on climate change was entrusted to very different organizational settings over the years. The mandate on climate change moved from departments or units within one ministry to other, with frequently changing structure of the Ministries.

As climate change is a cross-cutting sector, it needs inter-ministerial collaboration and coordination. But the focal units on climate change, which presently is the CCMD under Ministry of Forest and Environment, faced hurdles in establishing inter-ministerial and cross-sectoral coordination and cooperation. There is still poor understanding and ownership of other ministries on climate change in general and the process of national communication in particular. As a result, there are missed opportunities to integrate climate change mitigation and adaptation programmes in sectoral and cross-sectoral plans and policies.

The engagement of relevant stakeholders in the TNC has limited only to scientific groups in Nepal. But engaging a much broader range of stakeholders is more desirable for a quality national communication. Efforts will be needed to expand engagement so that forthcoming communications ensure effective coordination of varying expectations, levels of knowledge and engagement, and articulation among a range of professional levels and personalities.

Similarly, vulnerability assessment did not explore potential synergies, and collateral benefits that exist between adaptation and mitigation. In addition, capacity building of national and sub-national actors was not sufficient, both within the government, universities and others. It is recommended to adopt a more integrated approach while preparing NCs, by developing national capacity and also ensuring institutional memory.

6.4. Financial Resources and Technical Support

The GoN received financial assistance of US$ 500,000 from the Global Environment Facility through United Nations Environment Programme to prepare the TNC. The project started in February 2016 and ended in November 2020.

In addition, Nepal has also received technical and financial support from UN Environment and NDC Partnership to undertake several activities (under National Adaptation Process Project and Climate Action Enhancement Package) that complement its TNC process. For example, NAP Project is undertaking Vulnerability Risk Assessment and preparing National Adaptation Plan which will document climate change adaptation options. Similarly, UNDP, Climate Analytics and GIZ are supporting MoFE for NDC enhancement and implementation support under the Climate Action Enhancement Package (funded by German Government) of NDC Partnership. GIZ has recently carried out technical assessment on the national GHG inventory of Nepal, focusing on three key principles to ensure quality of the inventory: completeness, transparency and accuracy.

Similarly, GCF has provided USD 39 million as a grant on the project "Building a Resilient Churia Region in Nepal," which seeks to enhance the resilience of ecosystems and vulnerable communities in the Churia region. It is conceived as a direct contribution to Nepal´s nationally determined contribution (NDC). GCF has also approved another project 'Improving Climate Resilience of Vulnerable Communities and Ecosystems in the Gandaki River Basin, Nepal' with a grant of USD 27 million. This project adopts an ecosystem-centered and community-based approach to reduce the vulnerability to climate change.

One of the major gaps in respect of these support comprise of the MoFE's capacity and process to mobilize resources across agencies that need both ownership of adaptation and mitigation actions. There was inadequate opportunity to invest resources into Ministries other than MoFE and to sub-national institutions for their engagement and capacity building. Similarly, there remains a missed opportunity of streamlining these resources in systematically contributing to national communication.

6.5. Capacity Needs

In the course of preparing this TNC, the Government of Nepal conducted assessment of the needs for capacity building in respect of addressing climate change. This covered information and analysis on capacity building activities, achievements, gaps and needs. The analysis covered assessment in terms of institutional, policy, legal and human resource dimensions for each of the thematic sectors identified in climate change policy 2019. In the assessment, capacity is considered for all

stakeholders, including government institutions, Universities, research organizations, local community and non-governmental actors. The following are the key gaps:

- Lack of effective convening power and coordination competence in MoFE and its CCMD in rallying the support of other Ministries both in the process of national communication process, and by implication securing the legitimacy in the eventual adoption of adaptation and mitigation measures suggested in the TNC
- Inadequate streamlining of support and resources
- Insufficient technical, institutional, and human resource competency and (equipment) infrastructure in DHM and other institutions for generating credible climate and environmental data
- Inadequate capacity development and awareness raising of government agencies, non-governmental organizations, and private sector associations in the TNC process.
- Insufficient acknowledgement of the capacity needs of federal agencies in thematic areas and cross-cutting areas as well as sub-national governments – especially local government entities and their representative bodies

Addressing the above gaps require greater engagement of MoFE with other federal ministries and sub-national governments and development partners. It also involves greater mobilization of resources for a whole-of-government as well as whole-of-society effort on tackling climate change, and institutionalized capacity to understand climate and communicate information and science to relevant stakeholders.

7. OTHER RELEVANT INFORMATION

7.1. Introduction

This chapter presents additional information relevant to Nepal's efforts at adaptation to and mitigation of climate change. Next sections of this chapter will cover the following themes:

- Efforts at integration of climate change into Nepal's development priorities, plans and programmes
- Technology needs assessment
- Climate change related research and systematic observation
- Education, Training and public awareness
- Networking and information sharing.

This information is based on brief reviews of existing policy and programmes, relevant literature, and consultation with government agencies and other stakeholders.

7.2. Integration of Climate Change into National Development

The preparation of this TNC included an assessment of the measures for the integration of climate change into national development priorities. It provides information on mainstreaming climate change into social, economic and environmental policies and actions. The review covered:

- Policies, strategies, plans and programmes for climate change integration in different sectors;
- Development priorities/projects and activities vis-à-vis budget allocations and expenditure;
- Implementation status and activities conducted by government, donor-funded projects and NGOs and INGOs;
- Main gaps and constraints in policy and plan implementation.

The result of the review on the integration of climate change adaptation and mitigation measures into eight thematic sectors is presented in detail in Annex 3. It identifies main policies and, for each of them, presents adaptation and mitigations measures. It also presents for each of these policies the measures related to cross-cutting themes, such as gender equity and inclusion (GESI), capacity building, livelihood improvement, empowerment, or research and studies.

The review shows that:

- Nepal overarching policies (Including 15th five-year plan) promote climate change integration in thematic sectors.
- Policies and plans in all thematic sectors emphasize strategies and measures for adaptation and mitigation
- Most of the relevant ministries have "climate change" focal points to communicate and monitor climate change related activities
- Donor-funded projects, INGOs and NGOs align at least part of their activities toward adaptation and mitigation measures in different sectors.
- Some research institutions have adapted their mandates in generating greater understanding of climate change and measures needed in specific sectors.
- Recent policies acknowledge and integrate cross-cutting themes such as gender equity and social inclusion (GESI) especially emphasizing on the participation of and benefits to

women, the poor, indigenous communities, and other marginalized groups; livelihoods, improving governance (especially greater decentralization and coordination).

- Implementation is going on as regular government or non-governmental sectors' activities, or in the form of specific schemes, programmes, or projects (such as REDD+, Nepal Climate Change Support Programme, Climate Model Programme, Adaptation for Smallholders in Hilly Areas (ASHA) Project, "Building a Resilient Churia Region in Nepal" project, "Adapting to Climate-Induced Threats to Food Production and Food Security in the Karnali Region of Nepal" project or payment for environmental services schemes).
- Some new laws, such as Forest Act 2019 facilitate the development of relevant projects or schemes in climate change adaptation or mitigation.
- In some aspects of policy implementation, federal agencies are supporting sub-national governments (provincial and local governments) as federal restructuring through the Constitution of 2015 has changed jurisdictions in several sectoral policy areas. In some aspects this transitioning from federal agencies has not been completed, creating confusion in some aspects.
- The implementation of policies requires the participation of and incentives to the private sector (such as in adopting new technologies or energy efficient or electric vehicles). There is less attention paid to the incentives needed for the private sector.

The review on climate change integration also shows that important institutional change has ensued recently, following the federalization of Nepal in 2015 and with the subsequent change of mandates in federal ministries. Two ministries (viz. Ministry of Forests and Soil Conservation and the Ministry of Environment) were merged to form the Ministry of Forests and Environment (MoFE). However, MoFE continues to face the challenge in coordinating with various sectors and Ministries and in aligning the priorities of the governments of all three levels. It further needs capacity to rally support and participation of civil society, private sector, academic institutions and international agencies for a coordinated action.

Another aspect of mainstreaming concerns with financing climate change. Climate finance involves many actors and agencies such as development partners, government institutions, UN agencies, multilateral development banks, I/NGOs, local institutions, and user groups. In government budget, the amount of expenditure marked as climate 'relevant' or 'highly relevant' has increased six-fold between the 2014–15 and 2017–18. For FY 2018/19, the proportion of the 'highly relevant' budget has increased from 15% to 20% from FY 2017/18 to 2018/19 (Freedom Forum 2019). A glimpse of allocated budgeted and expenditure is shown in Table 7-1 by their sources.

Table 7-1: Nepal's climate budget and expenditure, 2013/14-2017/18

FY	Total climate budget of Nepal, NRs Billion			Contribution in %		
	Allocated budget	Expenditure	Expenditure %	Government	Foreign grant	Foreign loan
2013/14	53.47	42.7	80	57	22	21
2014/15	66.34	50.6	76	56	23	21
2015/16	159.34	85.6	54	44	32	24
2016/17	201.61	115.6	57	44	14	42
2017/18	393.35	169.7	43	81	4	15

Source: MoF, 2018

In addition to on-budget foreign aid, some development partners provide off-budget funding for activities that include climate change. For instance, USAID-funded Hariyo Ban Programme was a US$39 million project from 2012 to 2017, followed by its second phase of US$18 million for the subsequent five years. Generally, it is found that the Ministries often struggle to spend their allocated budgets; in the fiscal year 2015/16, the budget utilization rate of selected Ministries was 60–80% (Freedom Forum 2019).

Key gaps and challenges. The following are key gaps, challenges and constraints in regard to climate change integration:

- It is not fully clear how vision and objectives of policies developed at the federal level cascade into the implementation at the provincial and local level.
- Some sectoral policies lack vision of holistic development with climate integration and of effective implementation, such as with identification of actors and allowing their participation
- Some are unclear about collaboration with provincial and local levels and on achieving effective coordination between different agencies.
- Some policies do not have supporting legislation, or detailed guidelines for effective implementation.
- In some sectors, cross-cutting issues such as Gender and social inclusion (GESI) are not acknowledged, or its criteria are not included in monitoring and evaluation or budgeting.

Ways forward. The analysis suggests that the agencies mandated with different sectors work in isolation, primarily as coordination is not legally binding and often formalistic, leading to weak implementation. Following are some of the ways forward for more effective climate change integration:

- Make further efforts to maintain a strong relationship between the national, provincial and local policies.
- Crosscutting issues (mainly GESI) should more thoroughly and meaningfully adopted in policy implementation, such as through participation of women and socially excluded groups in decision-making.
- Revise Acts and Rules related to water resources, energy and irrigation with inclusion of climate change adaptation and mitigation strategy.
- Broaden the consideration of risks in Urban Policy 2017 to include potential climatic disasters like floods, land erosion and landslides on top of existing focus on earthquakes.
- Develop policies and strategies for eco-industrial parks, transportation and infrastructure.
- Ensure the provision of incentives and support for adaptation and mitigation measures to the private sector.

7.3. Technology Needs Assessment

Technology is an important component for Nepal's ongoing and future adaptation and mitigation measures. Some technologies are already available and used. Indigenous people in Nepal, as elsewhere, have rich and diverse traditional knowledge and practices (UNFCCC, 2013; Nakashima,

Galloway, Thulstrup, Ramos, & Rubis, 2012). In many respects, they are also compatible with scientific knowledge and have great potential to address future challenges.

The Government of Nepal has undertaken technology needs assessment to identify, assess and prioritize environmentally sound technologies that will reduce the impact of climate change and its vulnerabilities. This section presents a snapshot existing and emerging technologies in each of thematic sectors identified in Climate Change Policy, 2019 (Table 7-2).

Table 7-2. Technologies available in Thematic Sectors

Thematic Sector	Mitigation Technology	Adaptation Technology
i. Agriculture and food security	• Multipurpose agroforestry system; • Energy efficient and low carbon emission technology for production, harvesting, processing and storage • Conservation agricultural practices;	• Climate resilient crops • Water efficient irrigation technology • Organic farming • Kitchen and home garden; • Dissemination of weather forecast information to farmers; • Insurance in Agriculture
ii. Forest, Biodiversity and Watershed Conservation	• Enhance and increase carbon sequestration • Financial incentives for carbon sequestration through REDD+ and Clean Development Mechanism (CDM)	• Agroforestry programme to protect steep slope and river • Development and implementation of wetland management plan • Development and implementation of management plan for conservation of endangered wild flora, fauna and ecosystem • Integrated watershed management for Chure conservation and vulnerable areas • Integration of best watershed and soil conservation practices as an adaptation program to build and enhance the capacity of local people • Management and control of disease, pest, invasive species and forest fire • Practice of Payment for Ecosystem Services (PES)
iii. Water resources and Energy	• Promotion of alternative energy and energy efficient technology	• Development of water storage, multiple use of water technology for easy access of water in

Thematic Sector	Mitigation Technology	Adaptation Technology
	• Use of environment friendly technology for development of hydropower, water and irrigation infrastructure	vulnerable area • Construction of rainwater harvesting pond • Setting standard for the sustainability of groundwater resource in urban area • Water siphoning in Glacial lake to prevent GLOF and reducing risk of water induced hazard • Establishment of meteorological station in different geological location for disseminating information on climate • Emergency Water, Sanitation Hygiene preparedness and response.
iv. Rural and Urban settlement	• Promotion of concept of green city/village, urban forestry and riverbank plantation • Provision of bicycle lane and footpath	• Organizing climate change mitigation and adaptation program in climate sensitive settlement • Setting standard for management of rural and urban settlement and infrastructure
v. Industry, Transportation and Physical Infrastructure	• Identification of sources of GHG emission and reducing emission through implementation of emission standard. • Promotion of energy efficient and electric energy • Use of environment friendly technology • Promotion of electric vehicles • Displacement and banning of old vehicles	• Reinforcement of climate induced landslide and flood management.
vi. Natural and Cultural tourism	• Use of alternative energy and energy efficient technology in tourism sector	• Diversification of tourism destination spot, foot and eco-trail development and maintenance • Dissemination of weather information and forecasting to tourist • Identification, management and conservation of climate vulnerable

Thematic Sector	Mitigation Technology	Adaptation Technology
		natural and cultural heritage
vii. Health, Drinking Water and Sanitation	• Development and dissemination of water efficient technology. • Reduction of hazardous solid waste generation at source by waste segregation in household, hotel and hospitals. • Proper management of solid waste and conversion of degradable waste into bio-energy. • 3R - Reduce, Reuse and Recycle of waste.	• Climate change induces disease and epidemic modelling, preparedness and prevention mechanism. • Increase safe drinking water accessibility with sufficient quantity. • Technology development for rain water harvesting storage tank.
viii. Disaster Risk Reduction and Management	• Monitoring of climate induced disaster and early warning system • Establishment of early warning and forecasting system on disasters • Adopt the rehabilitation, renovation and rescue against disasters • Mobilization of community institution for Disaster Risk Management	

7.4. Climate Change Research and Systematic Observation

The Department of Hydrology and Meteorology (DHM) is the responsible entity of hydro-meteorological observation in Nepal, which has an extensive network of meteorological, hydrological and agro-meteorological forecasts and early warnings on imminent climatic hazards. DHM, as a member of the WMO, expanding networking at regional and international levels. It exchanges hydro-meteorological data regularly within the network. Nepal currently works closely with Finish Meteorological Agency, Regional Integrated Multi-Hazard Early Warning System, ICIMOD, Asian Disaster Preparedness Centre (ADPC), SAARC (SAARC STORM), JMA, World Bank and weather and climate section of Bay of Bengal Initiative for Multi-Sectorial Technical and Economic Cooperation (BIMSTEC) to enhance the capacity and quality of the hydro-meteorological system of the country.

Climate and weather information is collected through its networks of manual and automatic weather stations. In addition to DHM, several other agencies are also involved in research and systematic observation at different aspects of climate change. For instance, research of NARC includes regional collaborative research on the application of CO2 enrichment technology in rice and inventory of meteorological database of different ecological belts of Nepal and analyse in relation to agriculture production system. Similarly, Alternative Energy Promotion Centre (AEPC) has experiential knowledge and publications on aspects such as biogas, Improved water mill, or renewable energy. Similarly, Nepal Climate Change Knowledge Management Centre under NAST conducts studies, publication and outreach activities such as Mobile Library for climate change awareness.

Among the international organizations, ICIMOD has been focusing on regional baseline data on cryosphere and climate change, inventory and monitoring of glaciers and glacial lakes, among others. Similarly, organizations such as CARE Nepal or Practical Action have worked in areas such as Climate Vulnerability and Capacity Analysis for local level adaptation planning.

Weather forecasting systems in Nepal are not very accurate because of the poor infrastructure and the deficiencies in the monitoring, forecasting, and giving warnings; particularly the extreme weather-related phenomena. Some of the hydro-meteorological stations located in deep gorges don't have communication even within the area of their coverage. They cannot transmit data on a real-time basis. The data formats used in a database management system are incompatible and absence of a web-based platform for sharing data and research, among institutions. The current financial resources are not sufficient to acquire and maintain hydro-meteorological equipment and hire skillful human resources.

Therefore, Nepal needs to improve by modernization of observations networks in accordance with the World Meteorological Organization (WMO) recommendations, with advanced computer-aided observation devices, instruments, and analytical equipment, as well as reliable communication systems. It further needs to improve and consolidate the exchange of environmental data with regional and global stakeholders; and address human and institutional (scientific, technical, equipment and logistics) capacities of DHM. It is also important to expand meteorological and hydrological networks and ensure required equipment and dependable energy in the stations.

7.5. Education, Training and Public Awareness

Education, training, and public awareness comprises a part of national communication as a supporting means of achieving national and global climate change objectives. The GoN, in the process of preparing this TNC carried out a review of the role of education to build knowledge, enhance skill, and raise awareness among the school and university students, local communities, and climate change practitioners.

Nepal internalizes education as a means of enhancing adaptation skills to climate change through the integration of climate change content into academic and professional training curriculums, including in schools and universities, as well as civil service training entity – Nepal Administrative Staff College. Climate and environment-related education is critical to transmitting knowledge and enhancing skill in order to promote local solutions to climate change mitigation and adaptation (Devkota and Phuyal, 2017, Adhikari et al., 2017, Bhuju, 2017). Training resource persons, school teachers and University faculty generally acknowledge the importance of climate change education and training. However, such commitments have not fully been practiced in terms of integrating climate change-related topics into every faculty curriculum.

Gaps in curriculum. The review of curriculums, carried out as part of this TNC reveal the following gaps in school and university education.

- Most of the courses confine contents to environmental-related introductory topics; only a few courses have integrated climate topics.
- Available climate change contents are mostly introductory and lack practical contents of climate change knowledge, including policies, implementation, resilience or links with livelihoods.
- Environment and climate topics in most University faculties, except in dedicated courses, are optional.
- Curriculums at all levels lack periodic revision to reflect new information and issues.
- There are inadequate consultations between curriculum development committee with the governments about the integration of environmental and climate topics in the curriculum and post-study human resources mobilization.

Gaps in Teaching and Materials. The following are identified as key gaps in teaching methods and materials in all levels of education.

- Teaching is mostly lecture-based and question-answer, and has limited components of field visit, observations, and case study.
- School teachers have limited training on contents and pedagogy, and especially lack updated information on climate change.
- Contents lack local examples of environment and climate change
- University students lack opportunities to engage with or learn from agencies and forums on climate change.
- There is insufficient sharing of knowledge between teachers, trainers and practitioners in climate change.

Suggested Activities. The review suggests the following key activities for effective education, training and public awareness.

- Necessary Improvement in the Curricula on content, periodic update and making more locally relevant
- Enhancement of teachers' competency and capability through training and updated materials.
- Integration of in-campus and outdoor learning as part of school, University and professional training.
- The provision of research grants for graduate students.
- Produce sufficient reference materials in Nepali and/or local languages and hands out about the textbook sections useful for both teachers and students.
- Inclusion of resources on climate change and environment in libraries of schools, university and professional training institutions
- Collaboration between school and universities with the focal government departments, research and development agencies

7.6. Networking and Information Sharing

In preparing this TNC, the GoN carried out a review the status of networking and information sharing on climate change in Nepal. The review identifies activities in networking and information exchange on climate change, key gaps and constraints and offers a set of activities that need to be undertaken.

The Department of Hydrology and Meteorology (DHM) serves as focal agency to work with World Meteorological Organization (WMO)in its Asia regional association. Accordingly, DHM becomes part of the WMO effort of the exchange of meteorological information, including for its use in sectors such as aviation, shipping, agriculture and water management. At Hindu Kush Himalaya region, DHM engages with ICIMOD which produces and disseminates environmental and disaster data to its member countries. ICIMOD provides a regional platform to facilitate knowledge sharing and cooperation on science and data; and provide opportunities for collating, curating, and sharing data for improved climate services.

Activities on networking and information exchange. The following present a snapshot of activities for networking and exchange of climatic information in Nepal:

- Sharing of information among scientists and other stakeholders through national and international seminars, symposia, workshops and training
- Publications from DHM, ICIMOD, NAST and others
- DHM website the hydrological and meteorological information accumulated nationwide
- DHM website and other information systems, e.g.,ICIMOD's has establish regional flood information system and regional database system
- ICIMOD's networking of scientists and practitioners across the region that share data and knowledge, and collaborate across borders.
- DHM communication of hydro-meteorological information and early warning of weather and floods to government bodies and the wider public.
- Regular global exchange of meteorological data by DHM as being a member of the WMO, the UNESCO's International Hydrological Program (IHP) and WMO's Operational Hydrology Program (OHP).
- DHM's engagement with and partnerships as being the focal point for IPCC and for the meteorological activities of the South Asian Association for Regional Co-operation (SAARC), and as national authority for The International Civil Aviation Organization (ICAO).
- Sharing of related information (e.g., policies, Acts, Regulations, disaster data) via DRR Portal by Ministry of Home Affairs.
- Research outreach activities from NAST through its knowledge management center.
- Information exchange and networking activities from international organizations and NGOs

Constraints in Networking and Information Sharing. The review for this TNC shows following major constraints or gaps in networking and information exchange.

- Insufficient technology, lack of competency, weak infrastructure at DHM
- Lack of institutionalization of knowledge within DHM as efforts are mostly project-based and top-down.
- Mismatch between the demand for and supply of climate change knowledge between DHM and local stakeholders.
- lack of updated and sufficient technology in most of the hydro-meteorological stations to collect and network the information, reducing efficiency and quality of data gathering, processing and analysis as well as networking processes.
- Lack of effective data sharing arrangement between DHM and other actors.
- Delays in updating webpages and data upload
- Insufficient outreach of climate science data beyond research institutions to actors such as in agricultural actors.
- Less readiness among other government agencies to properly utilize climate data and information.
- Lack of effective trans-boundary cooperation in sharing data on climate and flood

Way forward. The review for this TNC suggests undertaking following activities on Networking and Information Sharing:

- Adoption of technology as much as possible in collection and analysis of climatic information and its sharing.
- Enhancement of institutional and legal framework for the production and use of climate data amongst government entities
- Development of an overarching national strategy and roadmap on knowledge management to streamline ongoing initiatives on information gathering, analysis, exchange and use.
- Establishment of more representative network of hydro-metrological stations and early warning system, particularly focusing on higher altitude areas.
- Regular updates of the website and maintaining consistency (or avoiding redundancy) while producing and disseminating climate information
- Working with SAARC countries for multilateral exchange of flood data and climate information.

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9. ANNEXURE

Annex 1: Nepal Macroeconomic Indicators, 2006/07-2015/16

Indicators	Units	Fiscal Years									
		2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16*
Real GDP (At Basic Prices)	Rs. in Billion	494.00	522.00	543.00	566.00	588.00	615.00	638.00	674.00	690.00	695.00
Agriculture	Rs. in Billion	184.80	195.60	201.50	205.50	214.80	224.70	227.20	237.50	239.50	242.60
Industry	Rs. in Billion	86.80	88.30	87.80	91.30	95.20	98.10	100.70	107.80	109.40	102.50
Service	Rs. in Billion	243.50	261.40	277.10	293.30	303.30	318.50	336.80	357.70	370.50	380.40
Real GDP (At Basic Prices)	Change %/yr	2.8	5.8	3.9	4.3	3.9	4.6	3.8	5.7	2.32	0.77
Agriculture	Change %/yr	1.0	5.8	3.0	2.0	4.5	4.6	1.1	4.5	0.80	1.30
Industry	Change %/yr	4.0	1.6	0.6	4.0	4.3	3.0	2.7	7.1	1.50	-6.30
Service	Change %/yr	4.5	7.3	6.0	5.8	3.4	5.0	5.7	6.2	3.60	2.70
Per Capita GDP	USD	410.00	491.00	497.00	610.00	714.00	702.00	708.00	725.00	762.00	752.00
Per Capita GNI	USD	414.00	496.00	502.00	614.00	718.00	708.00	714.00	737.00	775.00	766.00
Per Capita GDP	USD	410.00	491.00	497.00	610.00	714.00	702.00	708.00	725.00	762.00	752.00
Per Capita GNI	USD	414.00	496.00	502.00	614.00	718.00	708.00	714.00	737.00	775.00	766.00
Per Capita GDP (In 2000/01 Price)	Rs.	21129.00	22110.00	22793.00	23561.00	24144.00	24962.00	25646.20	26820.10	27184.00	26972.30
Per Capita GNI (In 2000/01 Price)	Rs.	21569.00	22567.00	23301.00	24152.00	24664.00	25582.00	26396.80	27939.30	28261.00	28110.10
Gross Consumption/ GDP	%	90.20	90.20	90.60	88.60	86.00	89.00	89.40	88.10	91.20	94.70
Gross Domestic Saving/GDP	%	9.80	9.80	9.40	11.40	14.00	11.00	10.60	11.90	8.80	5.30
Gross National Saving/GDP	%	28.60	33.20	35.90	35.90	37.00	39.50	40.70	45.70	43.90	42.90
Gross Fixed Capital Formation/GDP	%	21.10	21.90	21.30	22.20	21.40	20.80	22.60	23.50	27.70	25.00
Government Investment in Gross Fixed Capital Formation/GDP	%	3.40	4.00	4.50	4.50	4.70	4.70	4.40	4.80	5.20	5.90
Private Investment in Gross Fixed Capital Formation/GDP	%	17.70	17.80	16.90	17.70	16.70	16.10	18.10	18.70	22.50	19.10
Gross Capital Formation/GDP	%	28.70	30.30	31.70	38.30	38.00	34.50	37.00	41.00	39.00	34.00
Gap between Gross Domestic Saving and Gross Investment/GDP	%	-18.90	-20.50	-22.30	-26.80	-24.00	-23.50	-26.80	-29.20	-30.00	-28.70
Exchange Rate**	Per US Dollar =Rs.	70.5	65.0	76.9	74.5	72.3	81.0	88.0	98.3	99.5	106.5

Source: MoF, 2016.

Note: *estimated; **annual average of buying and selling rates. Acronyms: GDP- Gross Domestic Product; GNI- Gross National Income.

Annex 2: Adaptation action plans

Sector	Main Objective/Goal	Actions	Monitoring and Assessment Indicators	Time Frame	Budget Size	Implementing/Responsible Entities
1. Agriculture and Food Security						
1.1	To ensure food security through increasing agriculture production and productivity with sustainable farming and reducing climate change impacts	Coordination among central, province and local government and enhancement of the capacity of key institutions involved in Agriculture Development Strategy implementation	Well-coordinated, number of trainings, reports	Short term	Small	National Planning Commission (NPC), Ministry of Agriculture, Livestock Development (MoALD)
1.2		Securing food and nutrition of disadvantaged groups and rights to food by implementing land use policy	Number of household access to food, available of food in months, enhanced storage capacity	Short term	Small	MoALD
1.3		Strengthen research capacity of institutions and expanded it into provincial level and make responsive to aware farmers and agro enterprises	Established research institutions in province and set of mechanism to disseminate at local level	Medium term	Medium	DoA
1.4		Providing bio-fertilizers and promoting organic production	Number of households used bi-fertilizers, and quantity of production	Short term	Small	MoALD
1.5		Improving animal breeds appropriate for the Nepal farming systems conditions	Number of animal breeds, reports	Short term	Small	MoALD
1.6		Enhancement of resilient capacity of farmers to climate change, disasters, price volatility and other shocks	Number of farmers enhanced their capacity	Short term	Small	MoALD

Sector	Main Objective/Goal	Actions	Monitoring and Assessment Indicators	Time Frame	Budget Size	Implementing/Responsible Entities
1.7		Encouraging investment for agriculture commercialization by adopting modern technology with considering climate change scenarios	Amount of investment and number of new technologies in agriculture commercialization	Medium term	Medium	MOALD, Ministry of Finance (MoF)
1.8		Strengthening information system like agricultural production and market access to farmers and consumers	Progress reports	Short term	Small	Agriculture and Livestock Business Promotion Division (ALBPD)
2. Water Resources and Energy						
2.1	To protect, conserve and manage water sources, produce clean energy and promote alternative energy	Development of watershed management policy and plan with considering climate change adaptations	Developed policy and plan and approved	Short term	Small	Ministry of Energy, Water Resources and Irrigation (MoEWRI)
2.2		Restoration of ponds, conservation of wetlands, and promotion of rain water harvesting technique to cope with water resources scarcity	Number of ponds, wetlands, rain water harvesting schemes	Medium	Medium	Province government, Municipalities
2.3		Establishing the research stations to monitor the GLOF, river basins and other climate induced disasters	Functional research units	Medium	Medium	Department of Hydrology and Meteorology (DHM), Water and Energy Commission Secretariat (WECS)
2.4		Adoption of SMART irrigation systems and expanded equitably and viably and improved irrigation efficiently management	Number of SMART irrigation schemes	Medium	Medium	MoEWRI

Sector	Main Objective/Goal	Actions	Monitoring and Assessment Indicators	Time Frame	Budget Size	Implementing/Responsible Entities
2.5		Promotion of nonconventional energy sources (such as biogas, solar energy, and hydropower), and fuel-efficient technologies (such as bio-briquettes, improved cooking stoves) to reduce demand of firewood.	Number of schemes	Long term	Large	AEPC, WECS
2.6		Development of multipurpose including disaster resilient and cost-effective energy production and storage projects	Number of projects	Long term	Large	MoEWRI, Nepal Electricity Authority (NEA)
2.7		Extension of hydrological and meteorological networks of DHM in all districts and municipalities and informed to communities timely during climate induced disasters.	Number of DHM units at local level, information sharing mechanism	Medium	Medium	DHM
3. Forests and Biodiversity						
3.1	To maintain balance in environment and sustainable development through participatory forest, biodiversity and watershed	Formulation and execution of policy and plans (Climate change policy, NAPs)	Approval of national climate change policy 2019, NAPs	Short	Small	Ministry of Forest and Environment (MoFE)
3.2		Establishing mechanism of payment for REDD as national and Payment of Ecosystem Services (PES) for community income generation to sustain forest resources	Established mechanisms and number of houses benefitted under PES	Long term	Large	MoFE

Sector	Main Objective/Goal	Actions	Monitoring and Assessment Indicators	Time Frame	Budget Size	Implementing/Responsible Entities
3.3	conservation and share benefits of productions	Strengthen participatory and inclusive forest management and biodiversity conservation practices to enhance the resilient capacity of forest resources dependent communities	Number of households benefitted, reports	Short term	Small	Department of Forest Soil Conservation (DoFSC)
3.4		Establishment of research stations in range land, forest areas and protected areas to assess the status and trend of changes over time	Number of research stations, published research articles, reports	Medium	Medium	Department of National Park and Wildlife Conservation (DNPWC), Department of Forest Research and Survey (DFRC)
3.5		Promoting natural based solution activities (EbA and clean energy)	Number of projects and benefitted households	Medium	Medium	MoFE, AEPC
4. Public Health and Water, Sanitation and Hygiene						
4.1	To reduce vulnerability on human health through enhancing adaptive capacity	Strengthen surveillance on climate induced vectors, water and food borne diseases and scale up of diseases control programmes	Reports, publications	Medium term	Medium	Ministry of Health and Population (MoHP)
4.2		Preparation of sanitation and hygiene plan in climate induced disasters areas or extreme weather conditions and implement it	Prepared plan, number of households benefitted	Short term	Small	DWSS
4.3		Formation of immediate emergency/response Team for disaster from climate change	Functioning of information centre, provided equipment.	Long term	Large	Province government, Municipalities

Sector	Main Objective/Goal	Actions	Monitoring and Assessment Indicators	Time Frame	Budget Size	Implementing/Responsible Entities
4.4		Introduce/ update climate change and health related modules into school and university curriculum and informal education system	Updated curriculum, run class, reported	Medium	Medium	MoHP in collaboration with Curriculum Development Centre (CDC) of schools and universities
4.5		Establishment of knowledge centre and strengthen research capacity of institutions with information sharing mechanism to communities on health and climate change	Established centre, provided equipment, human resources, report	Long term	Large	Management Division/HMIS and HOs, Nepal Health Research Council
4.6		Developing climate resilient water safety plan and strengthening water quality surveillance	Developed water safety plan, report	Short term	Small	Ministry of Water Supply (MoWS), Department of Water Supply and Sewerage (DWSS)
5. Tourism, Natural and Cultural Heritage						
5.1	To develop safe, quality and tourism friendly attractive touristic centres in Nepal	Construction of eco-cultural circuit and trekking trails	Construction completion reports and Annual progress report	Medium term	Medium size	Ministry of Culture, Tourism and Civil Aviation, Department of Tourism
5.2		Establishment of digital tourist information centre	Functioning of information centre	Short term	Small	Ministry of Culture, Tourism and Civil Aviation, Department of Tourism
5.3		Application of early warning system in disaster prone area and weather information system to alert visitors about predicted weather status including weather	Established coordination between Ministry of and DHM and functioning of information system	Short term	Small	Ministry of Communication and Information Technology, DHM

Sector	Main Objective/Goal	Actions	Monitoring and Assessment Indicators	Time Frame	Budget Size	Implementing/Responsible Entities
		extremities				
5.4		Enhancement of efficiency of emergency preparedness and rescue team for immediate action in the climate related events of disasters	Number of trainings and participants, post training report	Short term	Small	Ministry of Home Affair, Ministry of Culture, Tourism and Civil Aviation, Department of Tourism
5.5		Identification of climate sensitive areas and conservation of the naturally, culturally, religiously and historically important monuments	Conserved monuments and heritages, reports	Long term	Large	Ministry of Culture, Tourism and Civil Aviation, Department of Archaeology
5.6		Promotion of ecosystem-based tourism practices	Established home stays in rural areas, promotions materials	Short term	Small	Ministry of Culture, Tourism and Civil Aviation, Department of Tourism, Municipalities
6. Infrastructure and Urban Settlements						
6.1	To develop climate resilient infrastructures, make liveable city and sustain services	Amendments or reformulating the existing building code, infrastructure design guidelines and policies to integrate the climate change adaptation options in the policies and plans at central, province and local level	Revised policies and plans	Medium	Medium	Ministry of Urban Development, Relevant Ministry of Province, and Municipalities

Sector	Main Objective/Goal	Actions	Monitoring and Assessment Indicators	Time Frame	Budget Size	Implementing/Responsible Entities
6.2		Revitalization or development of cities with approach of green infrastructure through the preservation and including green space such as agriculture, parks and water holes and rivers to reducing the urban heat island.	Developed new safe and resilient cities	Long term	Large	MoUD, Department of Urban Development and Building Construction (DUDBC)
6.3		Encouragement for using renewable energy in housing, electric vehicle, and solar energy	Number of houses and persons used alternative energy	Short term	Small	MoUD, MOEWRI, AEPC
6.4		Awareness to people and communities living in climate induced disaster-prone areas and relocation of risky settlements in safe area.	Number of people awared and relocated their houses	Short term	Small	Municipalities
7. Climate Induced Disasters						
7.1	To prepare for reducing effect of climate induced disasters and effectively response it	Supporting to develop local level disaster risk reduction plan and implement it effectively	Developed DRR plans at local level, reports	Short term	Medium	Province Government, Municipalities
7.2		Establishing the research stations to monitor the GLOF, river basins and other climate induced disasters	Functional research units	Medium term	Medium	DHM, WECS
7.3		Strengthen the capacity of disaster response team with well-equipped and trained in each provinces and municipality	Strengthen capacity, functional unit, report	Medium term	Medium	MoHA, Provinces and Municipalities
8. Gender and Social Inclusion						

Sector	Main Objective/Goal	Actions	Monitoring and Assessment Indicators	Time Frame	Budget Size	Implementing/Responsible Entities
8.1	To operationalize gender sensitive climate efforts to promoting gender equality and inclusion in Nepal	Ensuring equal representation of women in decision making at climate change policy, programme, strategies and project	Number of women in decision making position	Short term	Small	Ministry of Women, Children and Senior Citizen (MoWCSC)
8.2		Developing and delivering special livelihood enhancement skills training in the areas of agriculture, forestry, livestock, micro enterprise, health, etc to the marginalized, poor and disadvantaged families	No of women benefitted and involved in trainings, reports	Long term	Large	MOFE, MoALD
8.3		Strengthen research capacity of women to identify disease patterns for new and emerging diseases and raise awareness through women groups	Disease patterns mapped, no of responses & early warning installed	Medium term	Medium	Research institutions, including academic institutions

Annex 3. Polices on Integration of CC into Development Priorities

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
A. Agriculture and Food Security			
National Climate Change Policy, 2019 *Policy 8.1- page 5-6* *Source: MoFE, 2019*	Promotion of Agriculture crops in dry and waterlogged area Promotion of water efficient irrigation system Promotion of crop diversification, Agro-biodiversity conservation and organic agriculture system. Provision of kitchen and home garden Vulnerability analysis of CC and planning of land use of agriculture area. Extension programme for keeping farmers informed about weather. Insurance provision for climate related risk/vulnerability in agriculture and livestock sectors.	Climate friendly agriculture system, Food security Livelihood improvement Agricultural crops protection technology Promotion of valuable species in Agro forestry in barren land Development of early warning information system technology for informing farmers about weather for precaution in agricultural crops. Energy Efficiency technology in agriculture and livestock for production, collection, processing and storage to reduce carbon emissions.	Provision of inclusion of poor, marginalized community, women, landless, indigenous people, vulnerable and disable people participate in the agriculturally based adaptation Agriculture based adaptation programmes conduct targeting to poor, marginalized, landless, ethic and vulnerable households, women and disabled persons Provision of documentation, promotion and expansion of indigenous knowledge, skills, practices and innovative technologies in agricultural system
Approach paper of the 15th Periodic Plan of Nepal 2019 *P-133* *Source: NPC 2019*	Goal: Competitive, climate adaptation, self-reliant or exported oriented agricultural sector transformation, inclusive and fulfillment of sustainable economic development	Budget allocation for farmers resilience capacity increment technology	Achieve inclusive and sustainable economic growth with transforming agriculture sector as competitive, climate friendly, self-reliant and export-oriented industry.

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
	-Use adaptation and resilience-oriented technology in agriculture -Agriculture biodiversity protection, promotion or sustainable utilization -Develop and promote climate adaptive and resilient organic agriculture technologies along with reducing climate change and its adverse impacts. -Ensure food and nutrition with continuing availability of food products, -Balance in consumption and its promotion through conservation, promotion and utilization of agro-biodiversity, -Development and expansion of climate change adaptation technologies.		
ADS (2015-2035) *P -10,44,49,50,51,60,67,68* *Source: MOAD 2015*	Promote stress tolerant varieties and breeds and establish early warning system, Pilot a farmer's welfare fund, promote agricultural insurance, strengthen the food reserve system, establish a fund for preparedness and response, Improve resilience of farmers to CC, disasters, price volatility and other shocks, agricultural commercialization, increase value	Provision of clean development mechanisms and disaster risk reduction Investment in climate Develop with Policy decision implement and scale up schemes related to PES including carbon sequestrations.	Gender Equality and Social and Geographic Inclusion

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
	added benefits to small holders' farmers and agro enterprises. -Introducing appropriation adaptation mechanisms to increase resilience of farmers to CC. -New technologies requiring continuous innovation and adaptation -Biodiversity conservation and climate change adaptation. -Improved resilience of farmers to climate change, disasters, price volatility and other shocks. -Research on stress tolerant varieties and Breeds. -Climate information and weather indexation systems, -Strengthen food reserve system, -Strengthen the seed and feed/fodder reserve system, -Improve capacity of extension staff and farmers in climate smart agricultural practices. -Establish a fund for preparedness and response, -Pilot a local-level weather -Indexing scheme.		

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
SEED VISION 2013-25 *P-20,23,27,45,50,57,66* *Source: MOAD (2013)*	Continued investment in crop breeding and maintenance including adaptation to climate change (P20) Contributing in biodiversity conservation and adapting to adverse impact of climate change, (P66) The development of new competitive varieties for the sustainable and competitive seed sector. Continuous use of local land races and other genetic resources for the development of diverse varieties in different regions by public, private and community sectors Maintenance of local diversity. Development and promotion of small-scale and location specific seed enterprises in each ecological region Contribute reducing genetic erosion and external dependence. Developing and promoting climate resilient crop varieties (drought, flood and heat tolerant, etc). Promotion of climate resilient	Increase crop productivity, raise income and generate employment opportunities through self-sufficiency and promotion of quality seeds. Biodiversity conservation and climate change	Creating an enabling environment to promote value chain with a focus on poor, women and disadvantaged communities. Promoting gender equality in collaboration with private and civil society organizations. Encouraging the participation of women and disadvantaged groups in producers‟ groups and labours‟ organizations. Minimizing entry barriers for women and disadvantaged groups in seed value chains. Improving income from seed value chains to women and disadvantaged groups. Conservation, climate change adaptation besides gender equity and social inclusion. Gender equity and social inclusion.

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
	seed varieties sensitize farming communities and allows for climate adaptation options in terms of food production. Reducing risks of farming communities, increasing livelihood options and strengthened capacity to adapt adverse effect of climate change.(P-66) Developing and promoting climate resilient crop varieties (drought, flood and heat tolerant, etc.) using rich biodiversity. Sensitize farming communities on climate change and allows for climate adaptation options in terms of food production.		
NARC's strategic vision (2011-30) *P-5,10,18,19,41,47* *Source: NARC 2010*	Developing resilience agricultural technologies to adapt and mitigate the climate change effects in agricultural sector as it has varied types of climatic zones from tropical to alpine range. Technologies develop for sub-sectors, prioritized and integrated among crops, livestock and fisheries. Decision support tools integrate different sub-sectors/	Estimation and development of mitigation measures of GHGs emission from agricultural crops and livestock Estimation of carbon sequestration under various agricultural practices and development of appropriate mitigation measures of GHG emission. Identification, development and promotion of climate friendly agricultural technologies to	Priority on indigenous knowledge, traditional practices and local resource

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
	commodities/ system with climate change scenario to assist planning and decision making for different stakeholders and policy makers.	adapt climate change Contribute to sustainable agriculture development for maintaining agro-ecosystems and agro-biodiversity. Develop methodology for the different agricultural crops area and yield estimation before harvest to improve preparedness to any extreme situations. Increasing capacity within NARC and other partners through collaborative research and jointly explore the adaptation and mitigation options.	
B. Forest, biodiversity and watershed			
Approach paper of 15th Plan (2019/20-2024/25) Topic no:6.1.6 Page 150 to 155 *Source: NPC, 2019*	-Conservation and management of forest, biodiversity and watershed -Agroforestry -develop the mechanism of Carbon trade and Payment for Ecosystem services	-Implementation of REDD + program -Green climate fund -Adaptation fund **(page 370)**	-Capacity building and empowerment -Documentation and registration of Indigenous knowledge and biodiversity
National Climate Change Policy, 2019 Policy 8.2- page 6 *Source: MoFE, 2019 a*	-Sustainable forest management -Agro-forestry -Wetland management -Species and ecosystem conservation (prepare and implement the plan) -Integrated watershed management	-Increase storage of forest carbon -REDD+ and CDM	-Capacity building of vulnerable communities -Increase access to information and technology -Climate resilience livelihood program -Scientific analysis of river, GLOF, wetland and sensitive

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
	-Provision of control and management of invasive species, pest and disease, drought and fire in the forest -Provision of Payment for Ecosystem Services (PES)		ecosystem
Environment Protection Act 2019 (Article 24) *Source: MoFE, 2019 b*	-Adaptation plan preparation and implementation	-Carbon trade (Article 28)	-Priority is given to women, disabled people, children, elderly people, poor and vulnerable communities
Forest Act 2019 *Source: MoFE, 2019 c* *Article 44*	-Payment for Ecosystem services Included private forest	-Carbon trade -Increase storage of forest carbon	-Women participation in the decision-making process
National Forest Policy 2019 *Source: MoFE, 2018*	-Community-based forest management practices -Integrated management of watershed -Fire prevention	-Development of green industries -Enhance carbon stock through REDD+	-Benefit-sharing in all forest management -Documentation and registration of Indigenous knowledge, skills, practices -Capacity building
National Ramsar Strategy and Action Plan, Nepal (2018-2024) Source: MoFE, 2018 b	-Water regulation -Wetland conservation	-Control of Soil erosion and settlement transport -Resilience to storms -Increase carbon stock	-Capacity building of federal, state and local stakeholders and engage them
Nepal National REDD + Strategy, 2018 *Source: MoFE, 2018 c*	-Increase plantation and ecosystem-based adaptation (EbA) -Minimize deforestation -Minimize forest degradation -Payment for ecosystem services (PES)	-Reduction carbon emission -Enhance carbon stock -Ecosystem resilience	-Equitable sharing of carbon and non-carbon benefits. -training and workshops for awareness creation (MoFE, 2018)

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
Nepal's Sustainable Development Goals (Status and Roadmap: 2016-2030) *Source: NPC, 2016*	-Conservation of forest biodiversity and watershed -Sustainable use of natural resources	-Reducing emission -Livelihood improvement	
National Park and Wildlife Conservation Act 2029 (5th amendment) 2017 Source: MoFE, 2017	-Wildlife conservation	-Conservation and management of (JAIBIK MARGA)	
Forestry Sector Strategy, 2016-2025 *Source: MoFSC, 2016*	-Increase forest, biodiversity, watersheds and climate-resilient capacity of the society -Use of local technologies for forest water storage -Stabilize soils and resist invasive alien species and pests	-Carbon stock increase -Reduce deforestation, -Forest carbon trade	-GESI forums at the national sub-national level and increase capacity of all stakeholders (MoFsc, 2016)
Fifteenth Periodic Plan, 2019 *Source: NPC, 2019*	-Natural resource conservation -Implementation of the local adaptation plan	-Reform policies and strengthen the legal framework and institutional settings -Adapted green development strategy	-Livelihood improvement through employment creation
Forest Policy, 2019 *Source: MoFSC, 2019*	-Forest management practices -Minimize deforestation	-REDD+ mechanism	-Capacity building

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
National Biodiversity Strategies and Action Plan (2014-2020) *Source: MoFSC, 2014b*	-Environmental monitoring -Low carbon economic development strategy formulation and revision -Climate change vulnerability assessment of ecosystems and species -Implementation of PES	-Improving connectivity -REDD+	-pursue gender equality and women's empowerment through a gender mainstreaming strategy
Community Forestry Development Guideline (2014) *Source: MoFSC, 2014a*	-Community adaptation plan preparation and implementation	-Improved forest qualities	
C. Water and energy			
15th Plan (2019/20-2024/25) Approach Paper *Source: NPC, 2019*	-Green development concept -Integrated watershed management -Conservation of traditional water ponds, stone taps, and springs	-Promotion and expansion of biogas, bio-briquettes, solar, improved cooking stoves, electric cooking stoves (Induction) -Micro and mini hydropower -Carbon trade/Green climate fund -priority to electrical vehicles	-Priority to GESI
National Climate Change Policy, 2019 *Source: MoFE, 2019a*	- Development of water saving technologies - Water collection ponds, rainwater harvesting and storage - Reduction of GLOF risk (Lowering) - Conservation of water sources	- Renewable energy and energy saving technologies - Development and promotion of water conservation techniques - Minimize multiplier effects	-Scientific analysis of river, GLOF, wetland and sensitive ecosystem (Knowledge and education)

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
Nepal National REDD + Strategy, 2018 *Source: MOFE, 2018c*		- Promote bio-briquettes, bio-gas, solar, wind and improve cooking stoves.	
Nepal's Sustainable Development Goals Status and Roadmap: 2016-2030 *Source: NPC, 2016*		- Electric vehicles, - Clean electricity generation, - Solar energy,	
National Energy Efficiency Strategy, 2018 *Source: MoEWRI, 2018*	- Reduce energy import - Implementing energy efficiency programmes	-Reduction in GHG emission - - Promote renewable and clean energy and energy efficient technology	- Awareness of energy efficiency to local women
D. Rural and Urban settlement			
Climate Change Policy 2019 *Policy:8.4, P-7,8* *Source:MoFE, 2019a*	Implementing CC mitigation and adaptation programme - Developing standards for rural and urban infrastructure management	Policy- Establishing climate friendly rural and urban settlement with safety, sustainable and infrastructure development Strategy- In local area, implementing land use planning with consideration of climate risk and allocate land of forest, agriculture and industry sector. Inclusion of less emission technology or adaptation programme during settlement expansion	

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
		Construction of rural and urban settlement on the basis of green village/city, plantation in barren land and construction of garden Managing people walking path and cycle lane during the road construction.	
National Urban Development Strategy 2017 *P-11,87,98,* *Source: MOUD (2017)*	Assessment and preparedness for earthquake and other disasters, e.g. flooding, land subsidence and slides. Promotion of a smart city that reduces ambient temperature, protects and preserves the natural environment, allows for the protection of biodiversity, helps reduce carbon footprint, mitigates the impact of CC and contributes to the environmental resiliency of communities. Natural cities (integrating farming Major strategies for improving urban environment include promotion of multi-hazard approach to deal with disasters and CC; promotion of urban agriculture; promotion of innovative art, architecture and	New approaches to urbanization and urban development in light of existing and emerging challenges of sustainability, increased resiliency and mitigation and adaptation to the effects of CC. Inclusive urban economies particularly in the context of increasing poverty trends in urban areas and the likelihood of increased refugees to urban areas for reasons of disaster and CC. Short-term or long-term vulnerability resulting from disaster or the regional/global impacts of CC. Planning and urban development should enhance capacity to cope with different types of hazards and	

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
	culture in new urban areas; facilitation of community and civil society organizations.	absorb shocks and risks. Promotion of multi-hazard approach to deal with disasters and CC; internalization of resilience perspective	
E. Industry, Transportation and Physical Infrastructure			
Climate Change Policy 2019 *Source:MoFE, 2019a*	-	Policy- Develop sustainable, low carbon technology industry, transportation development and climate resilience economic development concept Strategy- Industry or transportation surrounding GHG main point identification and causes and prepare mitigation standard and implementation Promotion of Energy efficiency technology development and electricity energy utilization in Industry, transportation and infrastructure development Use of Environment friendly and climate friendly technology during development of Industry transportation and infrastructure development. Use of climate risk reduction technology during infrastructure design and construction	

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
		Promotion of Electric vehicles use Reducing/Mitigating carbon emission of Aeroplane Industry and transportation by institutional and social accountability Removal of date expired vehicles and polluted vehicles gradually on the basis of specific standard.	
15th Period Plan of Nepal (2019-2023) *Source: NPC 2019*		Taking consideration of possible impacts of CC and its affects in the infrastructure construction Searching alternate way in the road during landslide and accidental cases Adopting precaution of CC and natural resources impact during construction of road, bridge and other physical infrastructure.	
Environment-friendly Vehicle and Transport Policy 2014 *Source: MOPIT 2014*		Promotion of Green city Reduce emission from transport sector, Increasing the share of electric vehicle up to 20% by 2020, Promoting the transformation of other regular vehicle to electric	

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
		vehicle and providing subsidy scheme for the promotion of electric and non-motorized vehicles. Avoid unnecessary travel, reduce trip distance, promoting the shift towards more sustainable transport modes such as non-motorized transport component in the transport plan, and further promotion of public transport systems. Focused on an improvement in transport practices and technologies through diversifying towards electricity, hybrid and natural gases; promoting progressive and affordable standards for fuel quality and regulating vehicle emissions in order to ensure compliance with air quality. Moving towards Environmentally Sustainable Transport System such as promotion of public transport system and bicycle use, introduction of fuel tax used in Kathmandu Valley for air	

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
		quality improvement and further promotion of non-motorized transport to contribute reducing pollution in urban areas	
F. Natural and cultural tourism			
15th Plan (2019/20-2024/25) Approach Paper *Source: NPC, 2019*	Renewable energy for tourism related organization	Use of Renewable energy	
Tourism Vision 2020 Source: MoCTCA, 2019	Change in design standard for tourism infrastructures Protect the tourism area	-Waste management, -Low carbon emission	-provision of enhancing the inclusiveness of women and other deprived communities -Employment creation -Enabling the institutional environment
Nepal's national tourism strategic plan 2016-2025 Source: MoCTCA, 2016	Awareness raising meeting, seminar, campaign Environment friendly tourism	-Zero carbon strategy	-Gender mainstreaming, -Capacity development -Employment generation
National Climate Change Policy, 2019 *Source: MoFE, 2019a*			-Institutional capacity development
Nepal National REDD + Strategy, 2018 *Source: MOFE, 2018 c*			
National Disaster Risk Reduction Strategic Action Plan 2018-2030 *Source: MoHA, 2018*	conservation of cultural heritage		
Nepal's Sustainable Development Goals Status and Roadmap: 2016-2030 *Source: NPC, 2016*	-Waste water treatment, increase in water efficiency		
G. Disaster Risk Reduction and Management			

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
Climate Change Policy 2019 *Policy -8.8, page -10,11* *Source: MoFE, 2019 a*	Integration of Disaster risk mitigation in the climate change adaptation plan and programme. Provision of Social Security to the climate disaster affected vulnerable people.	Climate Disaster Pre-informed System in the Federal, Provincial and Local level. Collection and forecasting of CC Information system	Ensure CC risk early warning system to reach in all class, caste and region.
National Policy for Disaster Risk Reduction 2018 Policy-7.22(P-15), 7.26 (P-16) ,7.34(p-18), Objective-5.3 (P-7) *Source: MOHA(2018) a*	Mainstreaming DRR in all development processes by integrating it with CC adaptation activities. [Objective 5.3] Promotion of CC adaptive infrastructure construction Development of CC adaptive agriculture system with the support from NARC, Nepal Academy of Science and Technology and other research centers. Flood, inundation and draught resistant and CC adaptive health service system [7.34]	Adopted Risk reduction policy conducting study for impact of disaster risks and CC during planning, designing, construction and management of the mega projects for development. [7.26]	Senior citizen, gender, people with disability and children friendly infrastructure development and building construction (7.22)
Nepal Disaster Risk Reduction National Strategic Plan of Action (2018-2030) *P-29,31,36,72,77,90,94,99,112,115,117,173,180* *Source MOHA (2018)b*	Developing climate smart villages and cities Developing climate smart Agriculture Research for DRR and CC adaptation Promoting research and development of construction technology, materials, infrastructure design, and management for "Build Back	Preparing and incorporating Initial and Comprehensive Risk Assessment Framework for development projects for the selection of major projects based on the disaster and CC risk related knowledge Conducting training on Climate and Disaster Risk Impact Assessment method	Senior citizen, gender, people with disability and children friendly infrastructure development and building construction (7.22) DRR and management and paying special attention to people disproportionately affected by disasters, especially the poorest.

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
	Better" in DRR and reconstruction and CC adaptation	Promoting the local resource based Green Infrastructure at province and local level Promoting alternative energy at the Federal, Province and Local level Tax and levy in the petroleum products for financing the activities for DRR and CC Adaptation. Supporting from private sectors through the CSR Global climate financing mechanism such as Green Climate Fund	Integration of gender, age, disability and cultural perspective in all policies and practices promoting women and youth leadership Conduct risk assessment and mapping in Nepal for each hazard including risk related information covering knowledge on vulnerability and capacity, and social, economic and demographic information with disaggregated data of gender, age, disability, and other indicators. Prepare and implement guidelines for the security of vulnerable groups and prevention of gender violence during emergency Implement gender sensitive and inclusive approach in all the processes of Disaster Risk Management Prepare Gender Equality and Social Inclusion action plan for DRR Follow Gender Responsive

Theme/ Sector and Policies	Adaptation	Mitigation	Cross-cutting
			Budgeting System while preparing the program and budget for DRR at Federal, Province and Local level Allocate adequate budget including GESI in annual programs in sectoral agencies

Annex 4: The 100-Year Global Warming Potential Values

GHG	Global Warming Potential
Carbon dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide (N_2O)	298
Hydrofluorocarbon (HFC-134a)	1300
Hydrofluorocarbon (HFC-23)	11,700
Tetrafluoromethane (CF_4)	6500
Hexafluoroethane (C_2F_6)	9200
Sulphur hexafluoride (SF_6)	23,900

Source: IPCC Fourth Assessment Report (IPCC, 2007)

Annex 5: Detailed GHG Emission and Removal/Sink as per Sector/Sub-Sector

Sector/Sub-Sector	Emission					Removal/Sink	Net Emission/Sink
	CO_2	CH_4	N_2O	HFC*	CO_2-eq	CO_2-eq	
TOTAL	**14667.22**	**1259.61**	**26.37**	**0.01**	**54028.73**	**25862.67**	**28166.06**
1. Energy	**4678.22**	**354.90**	**4.03**	0.00	**14751.66**	**0.00**	**14751.66**
- Energy Industries	2.38	0.00	0.00		2.38		2.38
- Manufacturing Industries and Construction	2237.34	0.04	0.06		2256.22	0.00	2256.22
- Transport	1708.92	0.27	0.08		1739.51	0.00	1739.51
- Others (Commercial/ Institutional, Residential, Agricultural)	729.58	354.59	3.89		10753.55	0.00	10753.55
2. Industrial Processes and Product Use	**355.40**	**0.00**	**0.00**	**0.01**	**368.40**	**0.00**	**368.40**
3. Agriculture, Forestry and Land Use (AFOLU)	**9631.24**	**882.36**	**21.12**		**37984.00**	**25862.67**	**12121.33**
- Livestock	0.00	705.49	0.09		17664.07		17664.07
- Land (Forest)	6715.02	0.00	0.00	0.00	6715.02	23792.83	-17077.81
- Land (Non-Forest)	2105.23				2105.23	2069.84	35.39
- Aggregate Sources and Non-CO2 Emissions Sources on Land (3C)	810.99	176.87	21.03		11499.68	0.00	11499.68
4 Waste	**2.36**	**22.35**	**1.22**		**924.67**	**0.00**	**924.67**

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