NEPAL
FIRST BIENNIAL TRANSPARENCY REPORT

Government of Nepal

Ministry of Forests and Environment

May 2025

NEPAL

FIRST BIENNIAL TRANSPARENCY REPORT

Government of Nepal

Ministry of Forests and Environment

May 2025

Senior Management
Dr Rajendra Prasad Mishra, Secretary, MoFE
Dr Deepak Kumar Kharal, Secretary
Dr Govinda Prasad Sharma, Secretary
Dr Maheshwar Dhakal, Chief, CCMD
Dr Sindhu Prasad Dhungana, Former Joint Secretary
Dr Buddi Sagar Poudel, Joint Secretary

Lead Coordinator
Dr. Shiva Khanal, Under Secretary, CCMD, MoFE
Assistant
Prakash Lamichhane, Research Officer, CCMD, MoFE

Editorial and Technical Team:
Dr. Shiva Khanal, Under Secretary, CCMD, MoFE
Suman Subedi, Under Secretary, CCMD, MoFE
Naresh Sharma, Under Secretary, CCMD, MoFE
Dr. Prakash Singh Thapa, Under Secretary, CCMD, MoFE
Bir Bahadur Rawal, Senior Divisional Engineer (SDE), CCMD, MoFE
Prakash Lamichhane, Research Officer, CCMD, MoFE
Rajan Thapa, National Project Manager, CBIT, WWF Nepal
Pradeep Bhattarai, Project Officer, CBIT, WWF Nepal

Published by
Government of Nepal
Ministry of Forests and Environment
Singha Durbar, Kathmandu, Nepal
Telephone: +977-14211567
Email: info@MoFE.gov.np

Citation
MoFE. (2025). Nepal First Biennial Transparency Report. Ministry of Forests and Environment(MoFE), Government of Nepal. Kathmandu, Nepal.

Front cover: Khumbu valley Photo by: Bharat Bandhu Thapa Copyright: www.bharatbandhu.com.np ;
Back cover : Rara Lake, Mugu by: Janak Acharya

MESSAGE FROM THE HONOURABLE MINISTER

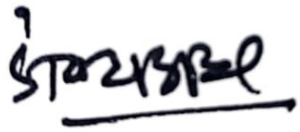
Climate change stands as one of the most defining and complex challenges of our time, demanding urgent, sustained, and cooperative action from the global community. For a country like Nepal, with its unique geography, rich biodiversity, and diverse cultures, the impacts of climate change are not a distant threat but a present and growing reality. From glacial retreats in the Himalayas to erratic rainfall and extreme weather in the lowlands, our natural and socio-economic systems are already bearing the consequences. Millions of Nepalese whose livelihoods are dependent on climate-sensitive sectors such as agriculture, water, and energy face escalating risks to their well-being and security.

Despite these vulnerabilities, Nepal has remained steadfast in its commitment to climate action. Grounded in a strong policy foundation including the National Climate Change Policy (2019), the Nationally Determined Contributions (NDCs), the National Adaptation Program of Action (NAPA), Local Adaptation Plans of Action (LAPAs), and the National Adaptation Plan (NAP 2021-2050), Nepal has taken decisive steps to build climate resilience.

This First Biennial Transparency Report (BTR1) represents a significant milestone in our climate journey. It presents a snapshot of Nepal's climate actions and transparency efforts, including the status of GHG emissions, progress towards NDC targets, adaptation measures, and capacity support flows. The report also lays the foundation for defining quantitative, sectoral emission reduction targets, which are essential to projecting a credible path toward our net-zero ambition by 2045. While challenges such as limited technical capacity and access to climate finance remain, our resolve to uphold the goals of the Paris Agreement is unwavering.

I would like to express my sincere appreciation to all those who contributed to the development of this report, especially ministries, departments, sectoral experts, academic and research institutions, local governments, civil society organizations, the private sector, and international development partners. Your commitment and collaboration have been instrumental in shaping this report and advancing Nepal's climate agenda.

This BTR is both a reflection of our climate progress and a call to deepen ambition, foster solidarity, and act with urgency. Let us move forward together for the betterment of today and the future.



Ain Bahadur Shahi Thakuri
Ministry of Forests and Environment

FOREWORD

The global climate crisis represents not only an existential threat to our planet but also a formidable test of collective resolve, equity, and innovation. For countries like Nepal, this crisis carries profound implications for sustainable development, human well-being, and environmental integrity. As climate change is a global concern, the world should be aware of the climate change activities being carried out throughout the globe. In this context, Nepal has prepared its First Biennial Transparency Report (BTR1), marking a significant milestone in our commitment to the Paris Agreement and the Enhanced Transparency Framework to the United Nations Framework Convention on Climate Change (UNFCCC). This will play a significant role in communicating Nepal's status in climate change activities.

As the Chair of the Project Steering Committee, I take immense pride in presenting this BTR1, which offers a comprehensive account of Nepal's GHG inventory, climate finance flows, and progress on adaptation and mitigation actions. The report reflects our nation's enduring resolve to integrate science, policy, and practice in confronting the climate emergency. It demonstrates Nepal's progress in institutionalizing transparency, strengthening data systems, and enhancing evidence-based policy making in line with global best practices.

The report also reflects years of groundwork laid by previous climate initiatives, including the National Adaptation Plan, Nationally Determined Contributions, and the Greenhouse Gas Inventory System. I recognize the contribution of the past leadership of the Ministry of Forests and Environment and the Climate Change Management Division, whose pioneering work on climate data and transparency has enabled the current generation to build upon a strong and credible foundation.

This achievement has been made possible through extraordinary collaboration. I would like to acknowledge with deep appreciation the tireless efforts of the Climate Change Management Division and the BTR1 Project Execution Team, whose dedication and technical expertise laid the foundation for this nationally owned and scientifically robust report. The commitment of sectoral ministries, subnational governments, academia, and civil society partners has been instrumental in ensuring a whole-of-government and whole-of-society approach.

I extend my sincere thanks to all national and international partners who have supported this effort and call upon the global community to recognize the leadership of countries like Nepal in advancing transparency, ambition, and action.

Rajendra Prasad Mishra, PhD
Secretary, Ministry of Forests and Environment

ACKNOWLEDGEMENT

The submission of Nepal's First Biennial Transparency Report (BTR1) marks a historic moment in our country's climate governance journey, that aligns our national efforts with the global architecture of transparency, accountability, and ambition under the Paris Agreement. Anchored in the Enhanced Transparency Framework (ETF), BTR1 is a foundational tool to build trust, inform policy, and mobilize finance in support of Nepal's climate-resilient development.

The ETF represents a paradigm shift from fragmented reporting toward a unified, standardized, and iterative system that enhances clarity on countries' actions and support. Through this report, Nepal communicates its greenhouse gas inventory, progress on adaptation and mitigation, and support received, thereby contributing to the Global Stocktake and international trust building. It also serves as a critical diagnostic tool for identifying national capacity gaps and directing targeted interventions.

Preparing Nepal's BTR1 was a highly complex yet deeply rewarding process, led by the Ministry of Forests and Environment in close coordination with sectoral ministries, departments of this ministry, and development partners. I extend my profound gratitude to our Minister, State Minister and Secretary for their throughout support during entire BTR1 preparation work. I sincerely acknowledge the support from our departmental heads, sectoral focal points, and technical agencies who contributed data and insights across agriculture, energy, industry, waste, land use, and adaptation sectors. We are grateful to the consulting firm and its expert team, whose analytical support, modelling contributions, and facilitation were critical to the preparation of this report in accordance with UNFCCC reporting modalities and IPCC guidelines. Their collaboration helped navigate complex methodological and institutional challenges inherent in the transition to the ETF. A special recognition goes to the core report writing, editing and technical team lead by Dr. Shiva Khanal. I gratefully acknowledge the Global Environment Facility (GEF) for its generous financial support in the preparation of this Biennial Transparency Report, and the United Nations Environment Programme (UNEP) for its invaluable role as the implementing agency, providing strategic guidance and coordination throughout the process. While I may not be able to mention every distinguished contributor by name here, I extend my appreciation to all individuals and institutions acknowledged in the contributors list of this report.

BTR1 is both a product and a process that demonstrates Nepal's participation in the global climate regime and contribution to shape credible, transparent, and inclusive reporting. It lays the groundwork for future iterations, continued institutional strengthening, and enhanced climate ambition. As Nepal steps forward in this new era of climate transparency, we remain committed to advancing our national priorities while upholding our global responsibilities. Let this report stand as a testimony to what is possible when national commitment, technical integrity, and international solidarity converge.

Maheshwar Dhakal PhD
Chief, Climate Change Management Division

ACRONYMS

ADS	Agricultural Development Strategy
AEPC	Alternative Energy Promotion Center
AFS	Agriculture and Food Security
BCRWME	Building Climate Resilience of Watersheds in Mountain Eco-Regions
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
BTR	Biennial Transparency Report
CBD	Convention on Biological Diversity
CBFM	Community-Based Forest Management
CBS	Central Bureau of Statistics
CC	Climate Change
CCBC	Climate Change Budget Code
CCFF	Climate Change Financing Framework
CCMD	Climate Change Management Division
CDD	Consecutive Dry Days
COP	Conference of the Parties
CSO	Civil Society Organization
CWD	Consecutive Wet Days
DFRS	Department of Forest Research and Survey
DHM	Department of Hydrology and Meteorology
DMG	Department of Mines and Geology
DWRI	Department of Water Resources and Irrigation
FBWC	Forest, Biodiversity, and Watershed Conservation
FY	Fiscal Year
GBV	Gender-Based Violence
GCA	Global Commission on Adaptation
GCF	Green Climate Fund
GEF	Global Environment Facility
GDP	Gross Domestic Product
GEDSI	Gender Equality, Disability, and Social Inclusion
GESI	Gender Equality and Social Inclusion
GESILG	Gender Equality, Social Inclusion, Livelihood and Governance
GHG	Greenhouse Gas
GHI	Global Hunger Index
GRID	Green, Resilient, and Inclusive Development
HDWS	Health, Drinking Water, and Sanitation
HEP	Hydroelectric Power

HKH	Hindu Kush Himalaya
ICIMOD	International Centre for Integrated Mountain Development
ICS	Improved Cook Stoves
IMCCCC	Inter-Ministerial Climate Change Coordination Committee
IPCC	Intergovernmental Panel on Climate Change
ITPI	Industry, Transport, and Physical Infrastructure
IUCN	International Union for Conservation of Nature
LAPA	Local Adaptation Plan of Action
LPG	Liquefied Petroleum Gas
MOFAGA	Ministry of Federal Affairs and General Administration
MoFE	Ministry of Forests and Environment
MRR	Monitoring, Review and Report
MW	Megawatt
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NARC	Nepal Agricultural Research Council
NAST	Nepal Academy of Science and Technology
NBS	Nature-Based Solutions
NCCP	National Climate Change Policy
NCCSP	Nepal Climate Change Support Programme
NCEPCCM	National Council on Environment Protection and Climate Change Management
NDC	Nationally Determined Contribution
NDRRMA	National Disaster Risk Reduction and Management Authority
NEA	Nepal Electricity Authority
NPC	National Planning Commission
NRB	Nepal Rastra Bank
NSO	National Statistical Office
OPMCM	Office of the Prime Minister and Council of Ministers
PCCCC	Provincial Climate Change Coordination Committee
PPCR	Pilot Program for Climate Resilience
PROR	Peaking Run-of-River
PSP	Private Sector Participation
PVCA	Participatory Vulnerability and Capacity Assessment
RCP	Representative Concentration Pathway
REDD	Reducing Emissions from Deforestation and Forest Degradation
RUS	Rural and Urban Settlements
SAP	Strategic Action Plan

SASCOF	South Asian Climate Outlook Forum
TNCH	Tourism, Natural and Cultural Heritage
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States Dollar
VRA	Vulnerability & Risk Assessment
WBG	World Bank Group
WECS	Water and Energy Commission Secretariat
WFP	World Food Programme
WIM	Warsaw International Mechanism
WRE	Water Resources and Energy

Table of Contents

1 National Circumstances, Institutional Arrangements and Legal Frameworks

Nepal is a landlocked country that lies along the slopes of the Himalayan Mountains between China and India. It has a land area of 147,516 km^2 spanning 800-850 km from east to west, and 144-240 km north to south. Physiographically, it stretches between $80^{0}04'$ - $88^{0}12'$ E and $26^{0}22'$ - $30^{0}27'$ N, and has the largest elevational gradient in the world, extending from tropical alluvial plains as low as 67 meters above sea level (m asl) in the lowland Tarai to the Earth's highest mountain, Mount Everest at 8,848.86 m asl (FRTC, 2022, MoFE, 2021a).

This diversity creates five distinct physiographic regions and seven monsoonal climatic zones (Figure 1), each characterized by unique temperature and precipitation patterns. This stark contrast between Nepal's tropical monsoon, which delivers 89.9% of the annual rainfall over four wet months and the eight dry months, including winter and spring, highlights the challenge of managing water resources (MoFE, 2021a). This climatic dichotomy, too much rain during the monsoon and too little during the dry season, poses critical adaptation challenges. Nepal's altitudinal and physiographic landscape is major in accelerating climate hazards, such as landslides, floods, droughts, and Glacial Lake Outburst Floods (GLOFs), causing widespread loss and damage.

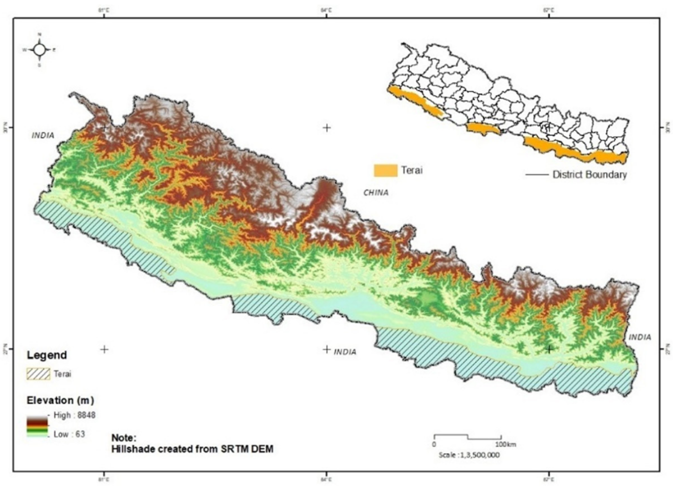


Figure 1: Map of Nepal

1.1 Population Profile

The country's population increased from 9.4 million in 1961 to 29.19 million in 2021 (see Table 1). However, the annual population growth rate has decreased from 2.66% in 1981 to 0.93% in 2021, indicating a demographic transition (NSO, 2021).

Table 1: Population and growth rate

Year	1961	1971	1981	1991	2001	2011	2021
Population (millions)	9.4	11.6	15.0	18.5	23.2	26.5	29.19
Annual growth rate (%)	1.65	2.07	2.66	2.09	2.24	1.35	0.93

The internal migration, defined as changes against the last registered prior residence, was 8,239,589 in 2021, which is 29.2 percent of the native-born population. The rate of recent migration shares the same percentage rate as the lifetime migration data (NSO, 2021).

Currently, approximately 66.03% of the total population of Nepal resides in municipalities, reflecting the significant milestone of urbanization in the country. The dense population is found in the major cities, such as the Kathmandu Valley and the cities of lowland Tarai (Figure 2). Regionally, 53.66% of the population lives in the Tarai, 40.25% in the Hill, and 6.09% in the Mountain region. The proportion of the population living in hills and mountains is projected to decrease to 47% by 2031. The number of people per household is decreasing, i.e., from 4.88 in 2011 to 4.37 in 2021. On the other hand, a remarkable increase in the proportion of the disabled from 1.94 to 2.2 and an increase in female-headed households by 5.5 percent in the same decade, an influential challenge in adaptation (NSO, 2021).

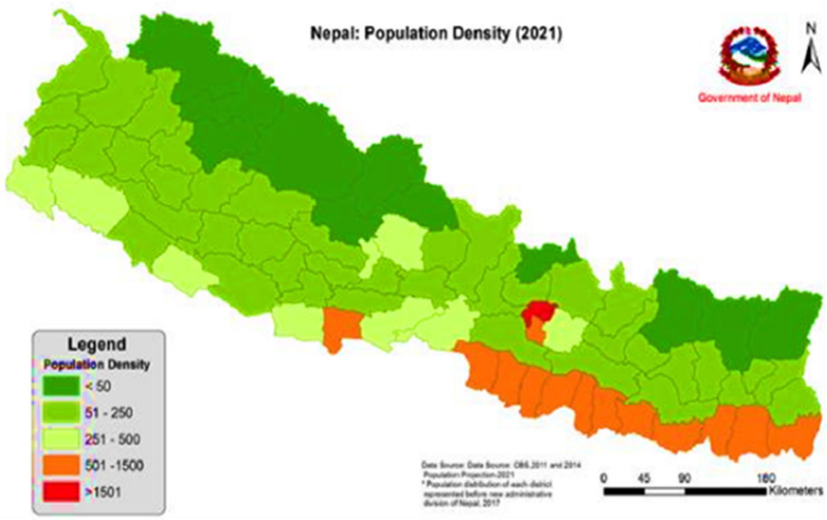


Figure 2: Population density (person/km²) in Nepal

As emphasized in the NAP, the growing population density in urban areas has increased their exposure to climate change vulnerability due to climate-induced hazards such as floods and landslides. These risks are often exacerbated by inadequate urban planning and underdeveloped infrastructure, thus failing to provide basic amenities to the growing urban populations. Moreover, urban environments face additional climate-related challenges, including the intensification of heat through the urban heat island effect, increasing water shortages, and heightened pollution levels. These factors amplify the impacts of climate change, emphasizing the need for resilient infrastructure and comprehensive urban planning to effectively manage the risk.

1.2 Economic Profile

Nepal is experiencing a structural shift in its economy, marked by a declining share of agriculture and a rising contribution from non-agricultural sectors to the GDP (MoF, 2023) (Figure 3). The country's GDP growth rate has been inconsistent over the years, with a significant rise after 2015 followed by a sharp decline during 2019–2020. While the average growth rate across the fourteen periodic plans was 7.4%, it dropped substantially to just 2.6% during the recently concluded fifteenth plan period. Between 2022 and 2026, Nepal is undergoing a transition from a least developed country to a developing nation (NPC, 2024). As of 2024, the country's GDP stands at NPR 5,348.53 billion, with a per capita income of USD 1,433.93 (MoF, 2023).

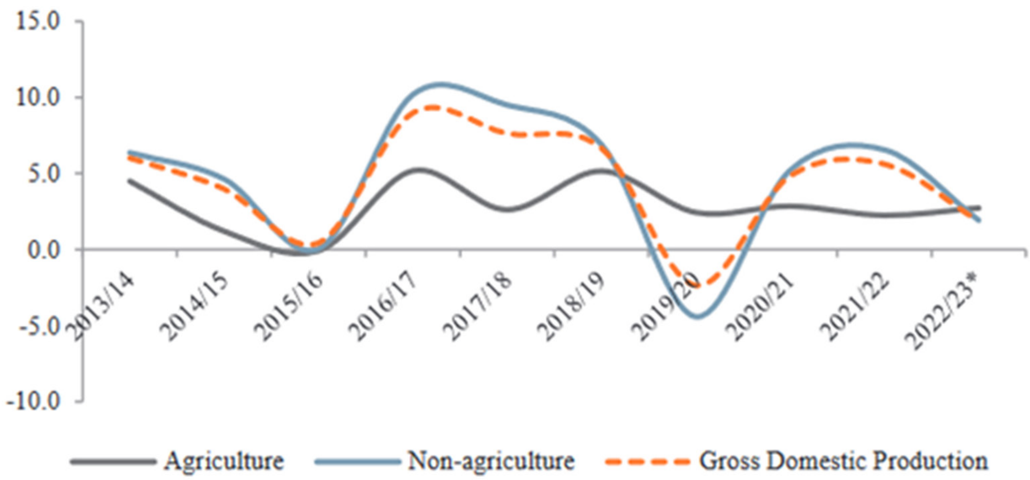


Figure 3: Gross domestic product growth rate in percentage

In 2022, the agriculture sector contributed 24.1% to GDP, and the non-agriculture sector contributed 75.9%. Agriculture remains the primary source of livelihood for a significant portion of Nepal's population, with about 62% of the total population relying on farming (MoF, 2023). Agricultural growth of 2.73% in 2023 was driven by a 6.9% rise in rice production but was limited by a decline in wheat, milk, meat, and eggs.

Meanwhile, non-agriculture growth slowed sharply to 1.92% from 6.56% the previous year, due to industry, construction, and retail trade declines, though other sectors grew. To sustain growth in this sector, Nepal must modernize agriculture through diversification and technology while fostering industrial and service sector expansion through infrastructure investment and productivity improvements.

The proportion of public debt to gross domestic product remained at 42.67% in 2081, slightly declining from 42.9% in 2080 (PDMO, 2024). The import of goods is around 10 times more than the export of the export. However, the trade deficit decreased by one percent in 2081 compared to the previous year, and the balance of payment situation is in surplus (MoF, 2024). Besides, the poverty level has decreased only by 3.5% over the past 10 years in 2024; the population living below the poverty line is 20.3%. Reliance on remittance has also increased, with remittances constituting around 27% of GDP in 2024. One of the income sources of 76.8 percent of households is remittance, and 72.4% of this income is used for daily consumption (NSO, 2024a).

1.3 Sectoral Details

1.3.1 Agriculture and Food Security

The arable land is the basis for Nepal's food security, agriculture's contribution to its GDP, rural employment, exports, and foreign exchange earnings. The agricultural household accounts for 62 percent of the total households of the country (NSO, 2023). The major crops grown in the country are rice, wheat, maize, millets, barley, and potatoes, whereas buffalo, cows, chicken, and pigs are major livestock.

The livestock population over the three years reveals a significantly declining trend (MoALD, 2023). The total livestock population in 2021 was 116,736,478, which declined by 6.2 % in the next year and with an additional decrease of 3.3% by 2023. Cattle, buffaloes, and sheep have experienced a consistent decline, with cattle dropping by 36.4%, buffaloes by 40.3%, and sheep by 36.7%. Similarly, pigs, fowl, milking cows, and milking buffaloes have also shown declines, with milking buffaloes experiencing the sharpest decrease of 47.8%. In contrast, goats have shown a steady increase of 8.2%, while ducks and laying ducks have experienced remarkable growth, increasing by 206.6% and 200.2%, respectively. Laying hens have also grown by 11.9%, following an initial dip. Similarly, with the exceptional increase of milk production of 5.4% and egg production by 7.6%, the meat production declined by 17.4%. Such drastic changes may lead to evolving agricultural practices, economic factors, or environmental challenges influencing livestock management.

Rice is the topmost cereal grown all over the country and a major staple food crop of the country (MoALD, 2023). The total annual production of cereal crops in Nepal displayed a mixed trend over the last three years. Production declined by 3.11% from 11.1 million MT in 2021 to 10.77 million MT in 2022, followed by a slight recovery of 1.31% to reach 10.91 million MT in 2023. This fluctuation highlights the sector's vulnerability to various factors, including climatic and economic challenges. On the other hand, the annual average production of cash crops shows a slight increase of 0.6%.

Nepal remains heavily dependent on agriculture for food security. Despite improvements in the production of major food crops and vegetables over the past decades, approximately 20% of the population still faces some level of food insecurity. While the 2024 Global Hunger Index (GHI) (GHI, 2024) indicates that hunger has reached moderate levels, malnutrition persists, with 24.8% of children under five years of age experiencing stunting. The adaptation gap is evident in Nepal's inability to fully meet domestic food needs, balance market supply and demand, and build resilience against environmental and economic vulnerabilities (WFP, 2022).

As revealed by the NAP report, women engaged in agriculture experience unique challenges from climate change compared to men, largely due to systemic inequalities such as limited access to resources, rights, and decision-making authority. These disparities leave women more vulnerable to climate impacts, exacerbating existing issues like the gender wage gap, restricted access to productive assets, and low labor force participation, despite noted progress. Additionally, Nepal's socio-economic vulnerability is heightened by factors such as geographical isolation, economic limitations, ethnic diversity, caste-based discrimination, and reliance on traditional livelihoods.

1.3.2 Forest, Biodiversity and Wetland

The forest area accounts for approximately 6.4 million hectares, covering 43.38% of its land area, with an additional 0.4 million hectares (2.8%) of other wooded land (FRTC, 2024). The total stem volume of Nepal's forests is estimated at 982.33 million cubic meters, with an average stem volume of 164.76 cubic meters per hectare (DFRS, 2015). Nepal's forests are categorized into ten major groups, including tropical, temperate, subalpine, and alpine scrub ecosystems.

Community-based forest management in Nepal has been widely acclaimed as the most successful approach for participatory forest management and its governance, with 23,457 community forests managing 2.59 million hectares, contributing significantly to forest conservation and biodiversity protection. Collaborative, leasehold, and religious forests also play roles in ensuring forest resource sustainability and community benefits. During 2001 and 2016, the country experienced significant tree cover loss with notable spatial and temporal variations. This phenomenon is accelerated due to over-reliance on forests for wood fuel, forest invasive species, illegal timber trade, forest fire, and unplanned developmental activities, such as road construction and hydropower projects (MoFE, 2018).

Nepal is rich in biodiversity, hosting over 13,000 plant species across 118 ecosystems, 75 vegetation types, and 35 forest types. This includes 12 global terrestrial eco-regions, with 350 endemic plant species and 14 endemic animal species. Nepal contributes significantly to global biodiversity, harboring 5.2% of mammals, 9.5% of birds, and notable proportions of gymnosperms and bryophytes. Its agricultural biodiversity includes over 550 crop species and 400 horticultural varieties (MoFE, 2018)

Protected areas cover 23.39% of Nepal's land, including 12 national parks, 1 wildlife reserve, 1 hunting reserve and 6 conservation areas, with buffer zones benefiting over 176,000 households. Conservation efforts have increased species populations like the one-horned rhino, Bengal tiger, red panda, and gharial crocodile. Nepal's wetlands, crucial for migratory birds and threatened species, face degradation due to encroachment, pollution, climate change, and invasive species. Biodiversity conservation remains challenging, with 298 species classified as threatened under the IUCN Red List, and domestic breeds like the Siri cattle extinct, and others endangered.

Wetlands of Nepal are diverse and productive ecosystems that cover about 5% of the country's area and support many endemic and endangered wildlife species. Wetlands include natural and artificial wetlands like rivers, lakes, reservoirs, marshes, ponds, and paddy fields. Nepal has 10 wetlands listed as Ramsar sites (Table 2) and has international recognition.

Table 2: List of wetlands listed in Ramsar sites

S. No	Ramsar Sites	Area (Km^2)
1.	Koshi Tappu	175
2.	Beeshazari & Associated Lakes	32
3.	Ghodaghodi Lake Area	25.63
4.	Jagadishpur Reservoir	2.25
5.	Gokyo & Associated Lakes	77.7
6.	Gosaikunda & Associated Lakes	10.3
7.	Phoksundo Lake	4.94
8.	Rara Lake	15.83
9.	Mai Pokhari	0.9
10.	Lakes Cluster of Pokhara Valley	261.06
	Total	605.61

Source: MoFE, 2018

1.3.3 Water Resources and Energy

Nepal, known for its abundant water resources with over 6000 rivers, has an average annual runoff of nearly 225 billion cubic meters. Rechargeable groundwater is estimated to range between 5.8 and 11.5 billion cubic meters (MoFE, 2020). The current water usage is approximately 28.8 billion cubic meters for irrigation, 0.5 billion cubic meters for industry, and 0.01 billion cubic meters for the service sector (MoEWRI, 2020).

Water security of Nepal is challenged by climate change, accelerating glacier melting, and expanding glacial lakes, unbalancing the water discharge. In 2020/21, hydropower production decreased by 6.9% due to reduced rainfall and river discharge (NEA, 2020). Future climate projections suggest increased water availability in some areas and reduced availability in others, with dry-season river flows potentially insufficient for hydropower. By 2100, renewable water availability may exceed the threshold for water stress, requiring adaptation strategies that improve water-use efficiency, diversify energy sources, and strengthen water infrastructure resilience (MoFE, 2021a).

The energy landscape in Nepal is primarily characterized by traditional fuels, with firewood, agricultural residues, and cow dung making up a significant 64.17% of total energy consumption. In addition, commercial sources such as coal, petrol, diesel, kerosene, LPG, ATF, and furnace oil account for 28.35%. Meanwhile, renewable energy contributes 2.52%, and grid electricity represents 4.96% of the overall energy mix (WECS, 2024).

Nepal's gross hydropower potential had been estimated at 72,544 MW (WECS, 2019). Nepal currently generates 3450 MW of hydroelectricity with an additional 500 MW under construction, in the solar sector, 800 MW is in pipeline, and 81.9 MW is already connected to the national grid. The total national energy demand from the grid is 48,655 MWh, and the national peak demand is 2,337 MW in 2024 (WECS, 2024). Nepal aims to generate 28500 MW (13500 internal consumption, 15000 export) by 2035.

The total population with access to the grid network has reached 99 percent (NEA, 2024). The number of connected customers from the national grid reached 5.47 million in FY 2023/24. The government has a strategy to mobilize finance to build large-scale hydropower projects, construct inter-country electricity transmission systems, and engage people, including remittance, for developing hydropower with national importance. Electricity production and infrastructure developments are highlighted in Figure 4.

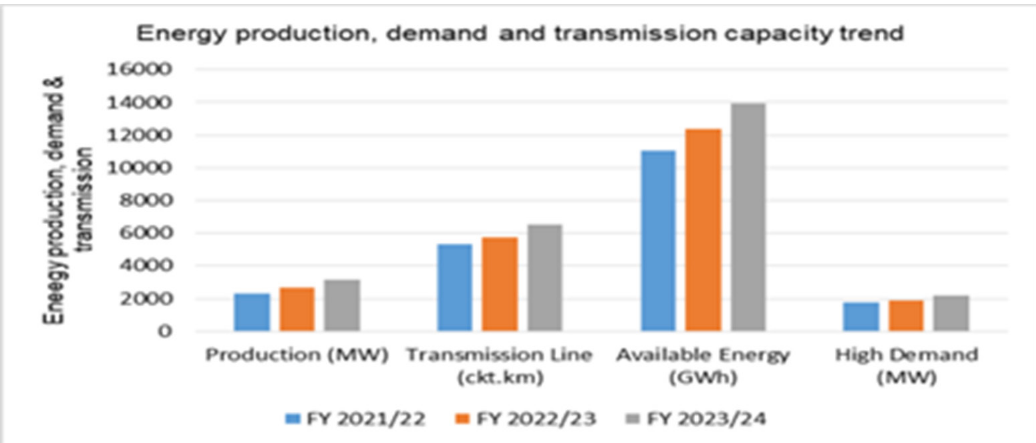


Figure 4: Electricity demand, consumption, production and physical structure

1.3.4 Industry, Transport, and Physical Infrastructures

The industrial sector contributes 13.45% of the national GDP (NRB, 2023). As of September 2024, 9519 industries were registered, including 1,491 large, 2139 medium, and 5,961 small industries. Industrial growth has been geographically uneven, heavily concentrated in Bagmati Province (MOICS, 2024).

The current infrastructure status of Nepal reflects significant progress across various sectors, demonstrating progress in connectivity, energy, urban development, and essential services. Transportation plays a crucial role in connecting Nepal's challenging terrain. Nepal had developed 34,339 km of federal roads, including 18,052 km of blacktopped roads, 7,696 km of gravel roads, and 8,591 km of earthen roads. Provincial and local governments contributed an additional 66,000 km to the road network. Nepal is gradually transitioning towards low-emission transport development pathways. According to the Department of Customs (2023), around 12.38% of all imported private four- and two-wheeler passenger vehicles were electric. In FY 2022/23, 4,232 out of 9,205 imported four-wheelers (46%) and 11,184 out of 115,364 imported two-wheelers (9.6%) were electric vehicles (EVs).

The Detailed Project Report (DPR) for the East-West Railway Network has been finalized, and the Terms of Reference (ToR) for Environmental Impact Assessments (EIA) have been approved section-wise for approximately 170 km; currently, 52 km out of the planned 68 km of the diesel-electric railway is in operation. Out of 54 domestic airports, 35 are operational, with new international airports inaugurated in Bhairahawa and Pokhara, enhancing air connectivity (NPC, 2024).

1.3.5 Tourism, Natural and Cultural Heritage

Nepal's tourism sector is rooted in its natural and cultural heritage, with expanding industries. In 2023, Nepal welcomed 1,014,882 tourists, a 65.05% increase from 2022, contributing $548.2 million. Tourism is a key contributor to the national economy as it is one of the sources of foreign exchange in Nepal. In 2022, foreign currency collections from foreign tourists visiting Nepal, driven by various objectives, increased by a significant 190.0%, reaching a total of Rs. 46.76 billion (MoF, 2023). According to the Nepal Tourism Board in 2023 (MoCTCA, 2024), the tourism industry contributed $2.7 billion to Nepal's GDP. Major attractions included trekking, mountaineering, holiday trips, and pilgrimage, with attractions accessible mainly during favorable weather. The tourism-recreation sector is recognized as a climate-sensitive economic sector. Trekking and mountaineering in Nepal are concentrated in Protected Areas that are at high risk of floods, landslides, glacier melt, avalanches, and GLOFs. Besides, many cultural heritage sites near rivers could be destroyed or heavily damaged by rising river waters, flash floods, and landslides (MoFE, 2021b).

1.3.6 Water, Sanitation, and Hygiene

In Nepal, climate change poses profound impacts on human health and well-being. The risks of vector-borne, waterborne diseases, respiratory infections, undernutrition, and mental illness have escalated. The most vulnerable and disadvantaged communities, such as women, the elderly, children, ethnic minorities, those who are disabled, and those who are destitute and displaced, are disproportionately affected by climate-sensitive diseases (CSDs) and health risks. The Tarai region had the largest concentration of cases of malaria (64%) and kala-azar (94%), whereas the Hill region had the highest concentration of cases of dengue (52%) and scrub typhus (44%) (MoHP, 2022). With rising mean temperature and precipitation, malaria cases are on the rise. Over the past decade, Kala-azar and Malaria cases have increased in Nepal's high mountains and hilly regions.

In Nepal, nearly 98% of households have access to improved drinking water sources. Among these, 86% have drinking water available on their premises, while 14% must fetch water, typically requiring a round trip of 30 minutes or less. About 43% of household members access piped water within their dwelling, yard, or neighbor's premises, while 8% rely on public standpipes and 38% use tube wells or boreholes. The use of improved drinking water sources has significantly increased from 65% in 1996 to 98% in 2022, with the share of households using piped water doubling from 22% in 2011 to 44% in 2022 (MoHP, 2023).

Water availability and quality are impacted by climate change in Nepal. Springs are the primary source of drinking water in the mid-hill region, and spring discharge has declined by 30% over the last 30 years. The increase in temperature also causes melting and thawing of glaciers, snow, and frozen ground, leading to changes in the seasonality of river flows and a reduction in water availability in summer (MoFE, 2021a).

Nepal reveals significant progress in improving access to sanitation facilities. By 2022, 92% of the population used improved sanitation facilities, with 27% having facilities within their dwelling and 67% in their yard or plot. This marks a dramatic increase from 3% in 1996 and 83% in 2016. Approximately 73% of the population had access to at least basic sanitation services, while 20% used limited sanitation services.

With rapid urbanization and changing consumption patterns, Nepal faces significant challenges in waste management, particularly in major urban areas. The total waste collection increased significantly from 26,666 metric tons in 2017 to 35,536 metric tons in 2019 (Table 3). A recent baseline survey conducted by the Central Bureau of Statistics, National Planning Commission, shows that the annual average total waste collected per urban municipality amounted to 2231 mt in 2016/17, 2164.4 mt in 2017/18, and 2232.7 mt in 2018/19 (CBS, 2020).

Table 3: Annual average waste collection per municipality by waste types and categories

S.N.	Waste Type	Year	Metropolitan City (mt/Year)	Sub-Metropolitan City (mt/Year)	Municipality (mt/Year)	Annual Average of Municipalities (mt/Year/ Municipality)	Daily Average of Municipalities (mt/Day/ Municipality)
1	Organic	2016	12,734.0	2,269.8	829.8	1,153.3	3.2
		2017	13,478.0	3,044.2	950.0	1,214.6	3.3
		2018	10,669.5	4,088.2	824.2	1,206.1	3.3
2	Inorganic	2016	8,787.0	1,005.7	518.3	698.0	1.9
		2017	9,725.0	1,338.7	504.6	666.8	1.8
		2018	7,100.0	1,525.9	551.9	743.5	2.0
3	Other	2016	5,145.0	213.5	155.6	283.0	0.8
		2017	6,200.0	229.7	177.5	283.0	0.8
		2018	6,200.0	229.7	177.5	283.0	0.8
4	Total	2016	26,666.0	3,503.5	1,543.0	2,231.0	6.1
		2017	28,469.5	4,596.3	1,610.2	2,164.4	5.9
		2018	23,969.5	5,843.7	1,553.6	2,232.7	6.1

Source: CBS, 2020

1.3.7 Disaster Risk Reduction and Management

From extreme heatwaves, cold waves, drought, GLOF, floods, landslides, and thunderstorms, Nepal is already facing severe climate change impacts, causing widespread 'loss and damage' with tragic implications for affected communities in Nepal. The devastating impacts of the climate crisis are most dramatically and tragically demonstrated by the recent extreme climate events that took the lives and livelihoods of all three regions: mountain, hill, and plain land.

Floods, landslides, epidemics, and fires are the major climate-related disasters in Nepal. A hazard-wise comparison of the deaths, affected population, and economic losses shows that epidemics caused the most deaths (52.8%), followed by landslides (16.7%) and floods (12.7%). Floods affected about 71%, followed by landslides (9.5%) and epidemics (8.2%). Fires caused the most economic losses (56.6%), followed by floods (31%) and landslides (3.7%) (MoHA, 2018).

Based on the available data on losses and damage from different climate-induced disastrous events between 1971 and 2019, about 647 people on average die from climate-induced disasters in Nepal each year. A devastating cloudburst in Dodhara Chandani, Kanchanpur, marked the highest recorded rainfall of 624mm in 24 hours to date in the history of Nepal. Continuous rainfall from July 3, 2024, led to severe flooding, inundations, landslides, and thunderbolts across the country, particularly impacting Sudurpaschim Province. Nepal has developed various strategies and policies; however, the primary emphasis remains on disaster response activities (NDRRMA, 2024).

1.3.8 Gender Equality and Social Inclusion, Livelihoods and Governance

Nepal's Gender Development Index (GDI) value increased from 0.75 in 1995 to 0.885 in 2022 (UNDP, 2023) (Figure 5), reflecting an 18% rise over 25 years with an average annual growth rate of 0.75%. The most notable progress occurred between 1995 and 2015, while the trend leveled off or slightly declined after 2015. The higher GDI values during earlier years were attributed mainly to greater participation of women in education. Assuming the same annual growth rate of 0.75% continues, the GDI is projected to reach 0.92 by 2025 and 0.96 by 2030. This improvement suggests that gender disparities may be reduced further (UNDP, 2020).

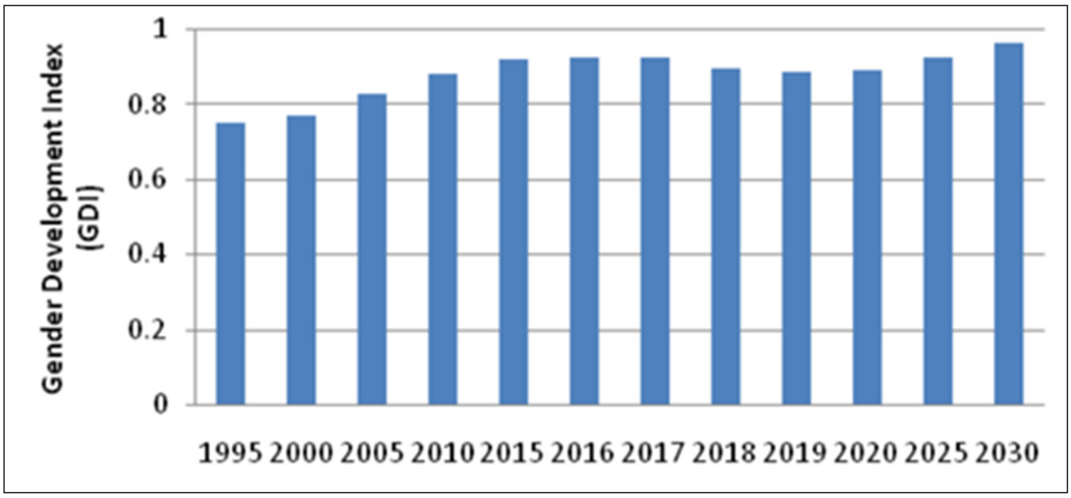


Figure 5: Trend and projection of gender development index (GDI) of Nepal

Nepal's Constitution ensures gender equality, granting women equal lineage rights and protecting LGBTQI individuals against discrimination. Seven-line ministries are implementing Gender Equality and Social Inclusion (GESI) policies to address gender-based violence (GBV) and promote inclusivity. GBV remains prevalent in various forms, influenced by cultural norms, with women disproportionately burdened by unpaid household work and time poverty. Women's ownership of land or property is limited to 19.71%, with urban areas showing slightly higher rates than rural regions. The gender wage gap is 29.5%, with women's labor force participation at 26.3%, compared to 53.8% for men (UNDP, 2023).

Despite representing 73% of the agricultural workforce due to male out-migration, women lack equitable access to resources like land, water, and training, making them vulnerable to climate shocks. Legislative measures, including constitutional quotas, have increased women's political representation to 33% at the federal and provincial levels, while ensuring rights for marginalized groups. However, intersectional factors such as caste and ethnicity continue to amplify vulnerabilities for rural and marginalized women. (MoFE, 2021c).

1.4 Climate Change Awareness Gaps in Nepal

As per the National Climate Change Survey 2022, among all households, only 35.8% were aware of climate change, while a significantly high proportion remained unaware across all three geographical regions. The Mountain region had the highest unawareness rate at 70.9%. Gender-wise, 61.3% of men and 74.0% of women were unaware of climate change impacts, highlighting the need for greater awareness efforts, particularly for women. Awareness levels also varied by location, with urban households (42.8%) being more informed than rural households 26.3% (NSO, 2024). Among ecological zones, households in the Hilly region (37.4%) were more aware than those in the Tarai (35.3%) and the Mountain regions.

1.5 Climate Change Profile

The impact of climate change is already a reality in Nepal. Ranging from the national economy to several other sectors like agriculture, livelihood, forest, and physical infrastructure, Nepal is already at the forefront of severe climate impacts, according to the climate change vulnerability and risk assessment report (2021). The average annual economic loss is about 0.08 percent of the FY2018/19 GDP (at the current price). Nepal's most devastating climate-induced disasters are floods, landslides, epidemics, and fires. Similarly, the policy recognized that increasing access to climate finance while establishing Nepal's climate change-related specialized issues as a common voice of countries at risk of climate change in an international forum is equally challenging.

For the detailed climate change profile, including trend projection, risk, and vulnerability, refer to chapter 5, **"Information Related to Climate Change Impact and Adaptation under Article 7 of the Paris Agreement."**

1.6 Legal and Institutional Arrangements

1.6.1 Legal, Policy Frameworks, and Regulations

Nepal has undertaken several policy initiatives and established institutional mechanisms to integrate climate change into development processes and adapt to its impacts. Nepal's constitution (2015) enshrines the right to a clean and healthy environment as a fundamental right, forming the basis for the country's commitment to addressing climate change. The Local Government Operation Act (2017) stipulates that Municipalities and Rural Municipalities are responsible for adopting low-carbon and environmentally friendly development practices. Specifically, Chapter 3, Article 11 of the Act outlines their authority to:

- Protect and manage various types of forests (community, rural, urban, religious, leasehold, and collaborative).
- Manage buffer zone forests, promote private forests, and carry out afforestation on open lands.
- Manage forest nurseries and promote local greenery.

Consequently, significant aspects of climate change policies and interventions are now managed at the provincial and local levels, with governments developing relevant policies, acts, guidelines, and laws at all tiers. Since federalization in 2015, Nepal has expanded its climate change coordination mechanisms to include sub-national levels, ensuring effective coordination among various organizations and functions. Several national policies have been developed to prioritize adaptation (Table 4).

Table 4: Major policy highlights for climate change adaptation and mitigation

Key policies, strategies, and regulations	Highlights
National Adaptation Programme of Action (NAPA), 2010	Identified nine priority adaptation programs across six sectors, setting a comprehensive response to climate change.
National Framework for Local Adaptation Plans for Action (LAPA), 2011	Provides a framework to integrate climate adaptation into local and national planning, emphasizing bottom-up, inclusive approaches
Climate Resilient Planning Tool, 2011	Developed by the National Planning Commission (NPC) to guide climate-resilient development planning.
Nepal Development Vision 2030, 2011	Emphasizes low-carbon development and the need for climate-resilient planning.
Climate Change Health Adaptation Strategies and Action Plans (2016-2020)	Focuses on public awareness, managing climate-related health risks, and protecting human health.

National Forest Policy 2019	Promotes sustainable forest management and equitable distribution of forest resources.
National Climate Change Policy 2019	Aims to build a climate-resilient society with sectoral and inter-thematic strategies.
National Environment Policy 2019	Ensures a clean environment through pollution control, waste management, and greenery promotion.
Environment Protection Act 2019	Consolidates environmental protection laws to safeguard the right to a clean environment.
Environment Protection Rules 2020	Covers pollution control, waste management, biodiversity conservation and enviornment impact assessment.
Sixteenth Five-Year Plan	Identifies climate change as a cross-cutting sector with objectives for mitigation, adaptation, and finance mobilization.
Second Nationally Determined Contribution 2020	Sets targets for a climate-resilient society and long-term low GHG emissions strategy.
NAP 2021-2050	Developed through a multi-stakeholder partnership, ensuring that decisions have been informed, socio-politically inclusive, transparent, and gender responsive. Emphasizing national ownership and building on the experiences of the NAPA, the NAP has been designed using a thematic working group approach aligned with the 8 thematic and 4 cross-cutting sectors identified in the NCCP 2019. It is recognized as an effective and successful model in adaptation planning.

1.7 Institutional Coordination Mechanisms

1.7.1 Climate Change Coordination Mechanisms at the Federal Level

National Council on Environment Protection and Climate Change Management (NCEPCCM): Established by the Environment Protection Act (2019, Article 32), this council is chaired by the Prime Minister and includes four ministers, seven chief ministers (one from each province), a member of the National Planning Commission (NPC), two professors, three experts, and the Secretary of the Ministry of Forests and Environment. The NCEPCCM oversees the integration of environmental and climate change matters into long-term policies, provides policy guidance to provincial and local levels, and manages resources for these areas (Article 34 (1a, 1c, 1d).

Inter-Ministerial Climate Change Coordination Committee (IMCCCC): Established by the MoFE, this committee is chaired by the MoFE Secretary. Its members include Joint Secretaries from 22 federal ministries, the NPC, and representatives from the Nepal Academy of Science and Technology (NAST), the National Agriculture Research Council (NARC), and the Alternative Energy Promotion Centre (AEPC). Additional members may be invited at the discretion of the MoFE Secretary.

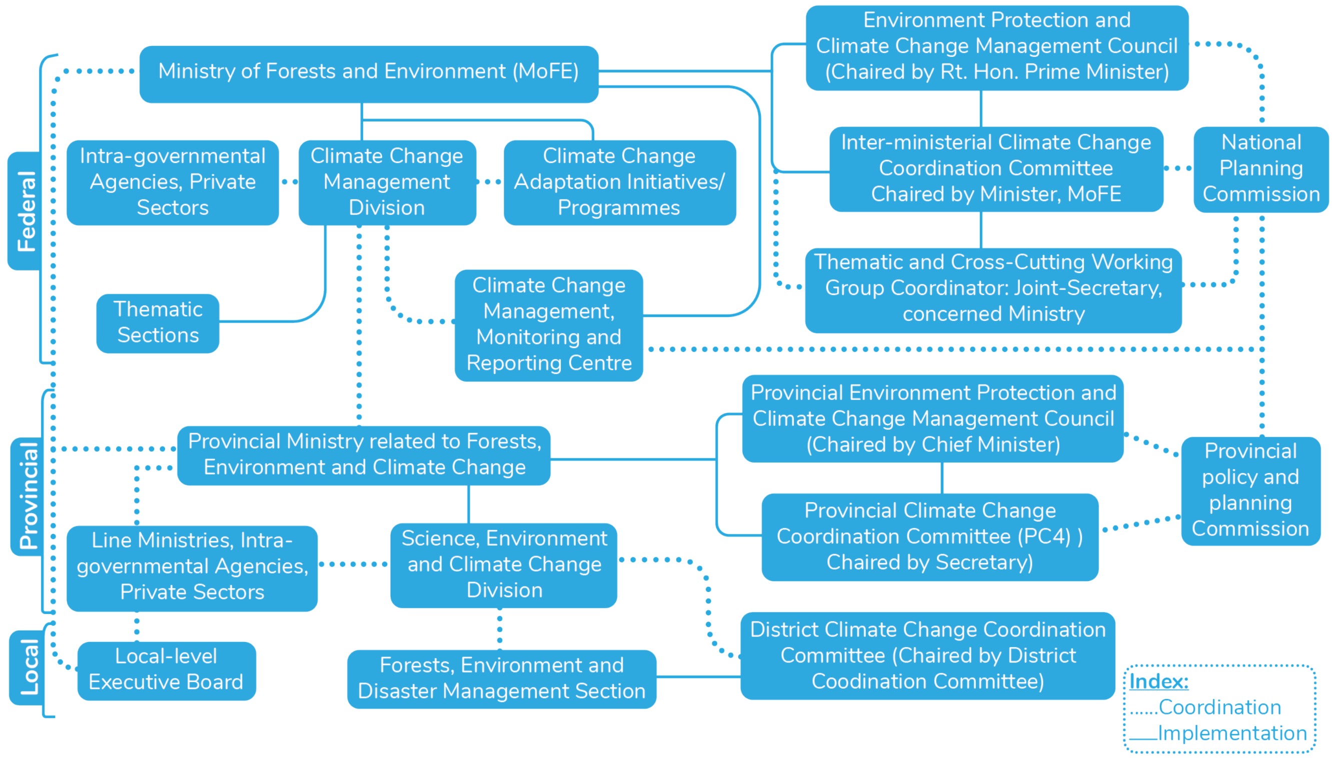
1.7.2 Climate Change Coordination Mechanisms at the Provincial Level

Provincial Climate Change Coordination Committees (PCCCCs): Each of the seven provinces has a PCCCC composed of provincial government agencies, civil society representatives, and local government officials. The Secretary of the Provincial Ministry, which is related to Forests and Environment, chairs these committees.

These mechanisms primarily function as horizontal coordination bodies. For vertical coordination, the Constitution mandates that the three levels of government operate on the principles of “cooperation, coexistence, and coordination." The Office of the Prime Minister and Council of Ministers (OPMCM) and the Ministry of Federal Affairs and General Administration (MoFAGA) facilitate communication from the federal level to sub-national agencies. For Functional coordination, NAST, AEPC, and NAARC are part of IMCCCC.

1.7.3 Climate Change Coordination Mechanism at the Local level

Forest, Environment and Disaster Management Section: This unit facilitates climate change activities, including adaptation, monitoring, evaluation of adaptation action, raising public awareness on adaptation, and implementing adaptation projects in areas under local jurisdiction. The institutional arrangement for the NAP implementation among the three tiers of government is presented in Figure 6.



(Source: GoN 2021-2050, NAP Report)

Figure 6: Climate change coordination mechanisms in Nepal

1.8 Capacity Building and Support

To monitor NDC implementation and meet the Enhanced Transparency Framework (ETF) requirements under the Paris Agreement, Nepal is developing a national MRV system and strengthening institutional capacities. Through the GEF-CBIT project, efforts are underway to establish ETF mechanisms within line ministries, sectoral agencies, and provincial governments. The proposed MRV system will enable these entities to effectively track and report climate actions, including (a) mitigation measures and GHG inventories, (b) adaptation efforts and national vulnerabilities, (c) technology transfer and technical support for mitigation and adaptation, and (d) international climate finance received, and domestic finance mobilized for climate actions.

1.9 Climate Finance

Nepal has systematically tracked climate-related expenditures within its annual budgets since 2013/14 through the Climate Change Budget Code (CCBC). This initiative identifies, allocates, and monitors government spending on climate-responsive programs. The trend of climate budget allocation highlights the government's increasing emphasis on climate-resilient development. For example, the allocations have grown to incorporate a range of priorities under Nepal's NDC and National Adaptation Plan (NAP). Nepal's Second NDC for 2021–2030 outlines the country's climate goals aligned with the Paris Agreement, aiming to pursue low-carbon development and build climate resilience. The total estimated cost of implementing the NDC is USD 33.04 billion. The government of Nepal has committed to contributing USD 3.4 billion through domestic resources. At the same time, the remaining USD 30 billion is expected to be sourced through international climate finance, bilateral and multilateral development partners, and private sector investments. The NDC focuses on key sectors including energy, transport, agriculture, forests, and water, with cross-cutting priorities such as gender inclusion, governance reform, and capacity building to ensure effective and equitable climate action.

The national adaptation plan NAP 2021-2050 has estimated the total budget of USD 47.4 billion, with approximately USD 2.1 billion needed annually. Due to internal revenue constraints, the Nepal Government has committed only USD 1.5 billion, leaving the remaining USD 45.9 billion to be sourced from international donors and partners.

Table 5: Sector-wise estimated costs for achieving the prioritized adaptation goals of Nepal

Sector	**Estimated Investment (USD)**
Agriculture & Food Security	2.5 billion
Forests & Biodiversity	2.8 billion
Water Resources & Energy	5.6 billion
Rural & Urban Settlements	2.85 billion
Industry, Transport, & Infrastructure	3.05 billion
Tourism, Natural & Cultural Heritage	1.13 billion
Health, Water, & Sanitation	4.75 billion
Disaster Risk Reduction	8.05 billion
Cross-cutting Areas (e.g., GESI, Capacity Building)	0.7 billion
Total	47.5 billion
National Contributions	1.5 billion
External Support	45.9 billion

Adapted from NAP 2021-2050

2 Overview of National Inventory Report of Anthropogenic Emissions by Sources and Removals by Sinks of GHG

Nepal is highly vulnerable to climate change despite its negligible contribution to global green house gas (GHG) emissions. The country's diverse topography and fragile ecosystems make it susceptible to the impacts of rising temperatures and changing precipitation patterns. The agriculture sector, which employs a significant portion of the population, is particularly at risk, with potential consequences for food security. Additionally, Nepal's water resources, including glacial meltwater, are threatened, impacting hydropower generation and water availability. Nepal's Third National Communication to the UNFCCC and its Second NDC highlight these vulnerabilities and outline the country's efforts to mitigate climate change and adapt to its impacts.

GHG emissions from Nepal's energy sector arise from stationary sources, such as manufacturing and residential activities, and mobile sources like road transport and aviation. Nepal's energy sector is a major source of emissions.

The IPPU sector in Nepal is an emerging source of emissions, driven by the growth in industrial activities such as cement production and the use of synthetic gases. Emissions from IPPU have been increasing as industrialization expands, and Nepal's contribution is expected to grow if mitigation strategies are not implemented.

In Nepal, the livestock sector is one of the major sources of GHG emissions, specifically methane (CH_4) from enteric fermentation that occurs in ruminant animals (i.e., cattle, buffalo, goat, sheep), which are the primary CH_4 producers. The emissions from the livestock sector have been increasing, driven by the increasing livestock population.

Nepal's predominantly agrarian economy contributes significantly to its national GHG emissions. The crop subsector of agriculture in Nepal is an important growing source of emissions, driven by the growth of agricultural activities such as intensive farming, increased use of chemical fertilizers, especially urea, and the increasing flooded rice farming due to irrigation facilities being developed steadily (GoN, 2019). Emissions from this sector have been increasing as chemical-intensive and commercial farming systems are on the rise, and their contribution to the country's total GHG is expected to grow if mitigation strategies are not implemented (Ritchie, 2019).

In Nepal, household, commercial, institutional, and industrial waste generation is the main driver of the country's waste sector, a growing source of emissions. As cities grow, emissions from the waste sector have been rising, and if mitigating measures are not put in place, Nepal's contribution is predicted to increase in the future.

2.1 Nepal's Policies and Regulations Related to Climate Change

Nepal's Forestry Sector Strategy 2016-2025

Nepal's Forestry Sector Strategy (2016-2025) is a 10-year plan (2016-2025) designed to guide the development of Nepal's forestry sector. It builds upon the Forest Policy 2015 and outlines five major outcomes: sustainable production and supply of forest products, improved biodiversity and ecosystem services, increased contribution to national economic development, inclusive and accountable forestry sector institutions, and a climate-resilient society. With a dedicated focus on creating a "climate-resilient society and forest ecosystems", this strategy involves adapting to climate change and mitigating its impacts through sustainable forest management practices. Promoting sustainable production and supply of forest products encourages reduced reliance on unsustainable logging and deforestation, which are major sources of GHG emissions. Furthermore, by improving biodiversity and ecosystem services, the strategy recognizes the vital role of healthy forests in carbon sequestration and climate regulation.

Nepal National REDD+ Strategy, 2018

The Nepal National REDD+ Strategy, 2018, is a comprehensive framework designed to reduce Nepal's deforestation and forest degradation emissions. It outlines the country's approach to REDD+ implementation, focusing on sustainable forest management, conservation, and enhancement of forest carbon stocks. One of the strategy's objectives is to reduce carbon emissions, enhance carbon stocks, and ecosystem resilience through mitigation and adaptation approaches by minimizing the causes and effects of the drivers of deforestation and forest degradation, and promoting sustainable forest management across ecological regions. The strategy emphasizes the importance of stakeholder participation, gender equality, and social inclusion in REDD+ implementation. It also recognizes the need for robust monitoring, reporting, and verification systems to ensure the effectiveness of REDD+ activities.

The Nepal National REDD+ Strategy, 2018, is crucial for guiding the country's efforts to combat climate change and promote sustainable forest management. It provides a roadmap for REDD+ implementation in Nepal, outlining the key objectives, strategies, and actions required to achieve the desired outcomes.

Nepal National Environment Policy, 2019

The Nepal National Environment Policy, 2019 (officially known as the National Environment Policy 2076) is a comprehensive framework designed to address the country's environmental challenges. It aims to integrate environmental considerations into all development activities, ensuring sustainable development for present and future generations. The policy emphasizes the need for sustainable development, recognizing the interconnectedness of environmental, social, and economic factors. It recognizes the urgent need to address climate change and promotes mitigation and adaptation measures. Furthermore, the policy focuses on effectively ensuring water resource use and promoting low-carbon technologies. Nepal National Environment Policy 2019 provides a roadmap for environmental protection and management in Nepal. It serves as a guiding document for policymakers, practitioners, and stakeholders in their efforts to create a sustainable and resilient future for the country.

Climate Change Policy, 2019

Nepal's National Climate Change Policy, 2019, aims to build a climate-resilient society and promote low-carbon development. It addresses the country's vulnerability to climate change impacts, such as glacial melt, extreme weather events, and changes in precipitation patterns. Key objectives of the policy include building a climate-resilient society, enhancing climate change adaptation capacity, promoting a green economy through low-carbon development, mobilizing national and international resources for climate action, and mainstreaming climate change into policies, plans, and programs. The policy outlines strategies for various sectors, including agriculture, forestry, water resources, energy, and urban development. It emphasizes the importance of adaptation measures, such as early warning systems, disaster risk reduction, and climate-smart agriculture. It also promotes the development of environmentally friendly livestock products and the reduction of emissions from animals and by-products. The policy aims to minimize the sector's carbon footprint by fostering innovation and sustainable practices while supporting economic growth. Additionally, it promotes mitigation actions, including renewable energy development, energy efficiency, and sustainable land use practices.

Second NDC, 2020

Nepal submitted its Second Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) in December 2020. This NDC represents a significant step forward in Nepal's climate action commitments.

Key features of Nepal's NDC include:

- Enhanced ambition: The NDC sets more ambitious targets than the previous one, particularly regarding renewable energy deployment and electric vehicle adoption.

- Expanded sectoral coverage: The NDC covers a wider range of sectors, including energy, agriculture, forestry, waste, and transport.

The NDC outlines specific targets and actions to be implemented by 2030, including:

- Increasing the share of renewable energy in the total energy mix.
- Promoting energy efficiency measures in various sectors.
- Expanding the use of electric vehicles.
- Protecting forests and promoting sustainable forest management.
- Implementing climate-smart agricultural practices.

Nepal's NDC is a crucial step in addressing the challenges posed by climate change and ensuring a sustainable future for the country.

Nepal's Long-term Strategy for Net-zero Emissions (LT-LEDS), 2021

Nepal's Long-Term Low Emissions Development Strategy (LT-LEDS) envisions achieving net-zero emissions by 2045, charting a comprehensive pathway for sustainable growth while addressing climate change. To realize this vision, the country is focusing on a multi-pronged strategy. This includes expanding renewable energy sources like hydropower, solar, and wind power, promoting energy efficiency in various sectors, and transitioning to electric mobility. Additionally, Nepal aims to protect and restore forests, implement climate-smart agricultural practices, and seek international cooperation for climate finance and technology transfer. Nepal's LT-LEDS also emphasizes the need for enhanced innovation, research, and development to drive low-carbon solutions across all sectors. Through this strategy, Nepal aims to balance economic growth with climate goals, creating a resilient industrial base aligned with its long-term vision of achieving net-zero emissions by 2045.

NDC Implementation Plan of Nepal, 2023

Nepal's NDC Implementation Plan lays out a detailed roadmap for achieving the country's emission reduction targets, aligning with its broader climate goals. It focuses on both mitigation and adaptation measures. For mitigation, the plan prioritizes the expansion of renewable energy sources, particularly hydropower, solar, and wind power, as well as improving energy efficiency in various sectors. To adapt to climate change, the plan emphasizes building climate resilience in agriculture, water resources, and infrastructure. Additionally, it prioritizes disaster risk reduction, early warning systems, and community-based adaptation measures. The implementation plan aims to mobilize domestic and international resources, strengthen institutional capacity, and promote public awareness to ensure its successful execution.

Furthermore, the NDC Implementation Plan highlights the importance of policy support and financial incentives to accelerate the shift towards low-emission technologies. This includes access to climate finance, government subsidies for cleaner technologies, and public-private partnerships to drive innovation. The plan also sets out a framework for capacity building, aiming to enhance the technical skills and knowledge of industry stakeholders and strengthen the regulatory environment to enforce compliance with emission reduction targets.

Lastly, monitoring and reporting are integral components of the plan, ensuring that progress in achieving NDC targets is regularly tracked and adjusted to meet Nepal's long-term goals.

Other Policies and Regulations Related to Climate in Nepal

Other policies, such as the Forest Act, 2019 National Forest Policy, 2019 Industrial Enterprises Act, 2020 Agriculture Development Strategy (2015-2035), National Biodiversity Strategy and Action Plan (2014-2020), and the Environment Protection Act (2019), indirectly encourage sustainable development practices. These policies, while not solely focused on GHG mitigation, include provisions that can contribute to emissions reduction. For example, provisions for regulating emissions from industries and promoting sustainable energy use. Similarly, the Agriculture Development Strategy includes measures to minimize emissions from agricultural production through climate-smart agricultural practices and renewable energy use. These policies collectively support Nepal's broader climate goals by promoting the safe and sustainable use of technologies, energies, and agricultural and land use practices.

2.2 Brief Overview of Nepal's National Communications on GHG

The estimation of GHG emissions in Nepal began in 1994, and the first national GHG inventory report (with 1990 as the base year) was published in 1997 by the Department of Hydrology and Meteorology (DHM) under the USAID implemented program from 1994 and 1997. The first officially submitted GHG inventory (with base year 1994) was prepared by the Climate Change Study Group and reported in Nepal's Initial National Communication (INC). Nepal's Second National Communication (SNC) was prepared by the Ministry of Population and Environment (MoPE), and it included the national GHG inventory with 2000/01 as the base year and was submitted in 2014. Third National Communication (TNC) prepared by the Ministry of Forest and Environment included the national GHG for the base year 2011 and was submitted in 2021.

2.2.1 National Institutional Arrangements on GHG Inventory System

The Ministry of Forests and Environment (MoFE) serves as the national focal point for GHG inventory management in Nepal, ensuring the development, archiving, and submission of the National GHG Inventory to the UNFCCC. The preparation of the GHG inventory for the period 2012-2022 and recalculation of the GHG inventory for the period 1994-2011 was led by MoFE through support from external consultants. The technical workgroup for the preparation of the GHG inventory consisted of experts in Energy, IPPU, Agriculture, Livestock, FOLU, and Waste sectors. Required data were collected from various sources, including literature, line ministries, government entities, private sectors, and associations. Some key sectoral line ministries that coordinated in providing data include the Ministry of Industry, Commerce, and Supplies (MoICS); the Ministry of Agriculture and Livestock Development (MoALD); the Ministry of Federal Affairs and Local Development (MoFAGA); and the Ministry of Energy Water Resources, and Irrigation (MoEWRI). These institutions play a critical role in coordinating with related organizations and other stakeholders to gather relevant activity data and emission factors.

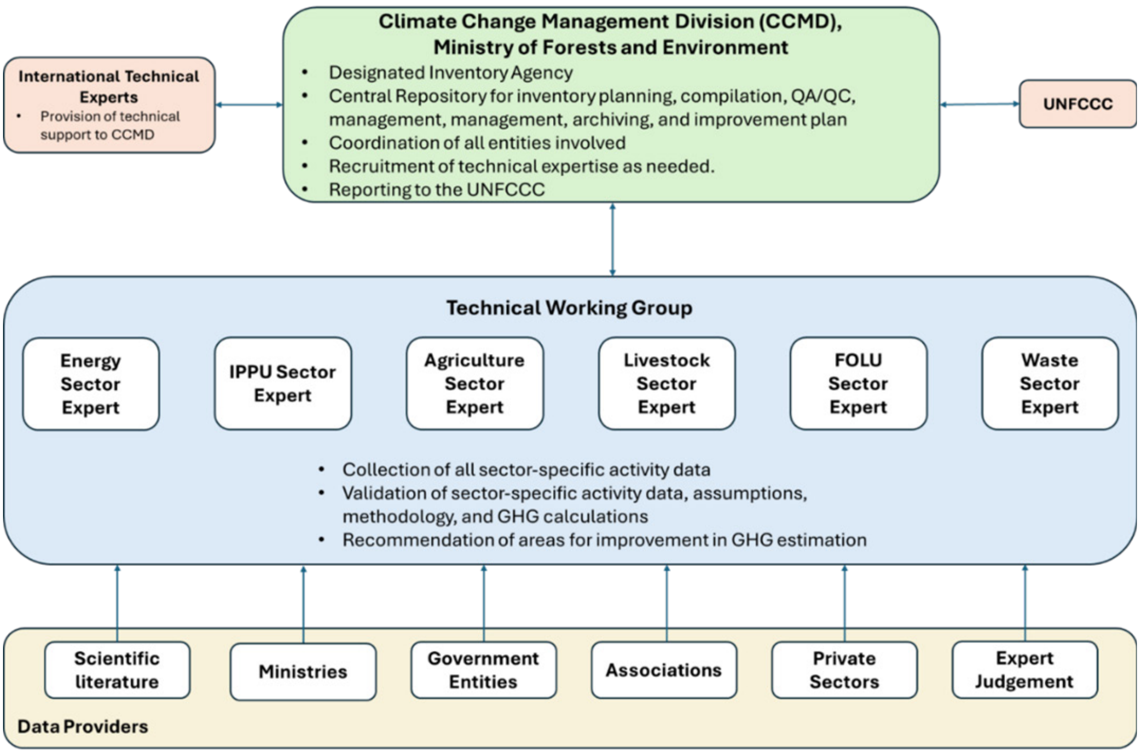


Figure 7: Institutional arrangements for Nepal's national inventory preparation

2.2.2 National Focal Point

The CCMD, MoFE is responsible for overall coordination, quality assurance, and oversight of GHG inventory processes, particularly working with stakeholders from relevant line industries, state-owned enterprises, development partners, industries, trade associations, academic institutions, local governments and private sector to gather and validate data for the preparation of national GHG inventory. Through multi-sectoral coordination and leveraging national and international partnerships, MoFE ensures the integrity and reliability of Nepal's GHG inventory, contributing to evidence-based policy-making and global climate action.

2.2.3 Inventory Preparatory Process

The preparation of the GHG inventory is led by MoFE. The MoFE prepares the inventory with the support from an external working group. The working group comprises team leaders and sectoral experts in energy, IPPU, agriculture, livestock, forestry, and other land use (FOLU) and waste sectors. This process is conducted in alignment with the IPCC 2006 Guidelines for National Greenhouse Gas Inventories, ensuring accurate and consistent estimation of emissions. Data sources include various line ministries, state-owned enterprises, local government, private sector, etc., and the use of emission factors specified by the IPCC or derived from national circumstances.

2.2.4 Overview of Inventory Planning

The GHG inventory for Nepal is developed through a structured planning process, which includes the identification of key emission sources. It also defines specific data collection methodologies and verification processes in line with the IPCC 2006 Guidelines. The planning process ensures that data collection is comprehensive, with relevant stakeholders engaged to ensure the accuracy of activity data and emission factors. Verification steps are built into the process to minimize uncertainties and maintain consistency with international reporting standards, such as the UNFCCC requirements.

2.2.5 Data Collection Process

Nepal currently lacks robust institutional arrangements for systematic data collection in preparation for the GHG inventory, and the process continues to be conducted on an ad-hoc basis. However, steps are being taken to improve and move towards an operational MRV with the support of the CBIT project. This will help Nepal to prepare a comprehensive document in the next cycle. The data collection process in the national inventory preparation is led by the sectoral experts. The sectoral experts identify the potential sources of data by scoping the categories, sub-categories, and types of GHGs. The data is requested from relevant line ministries, government divisions, state-owned enterprises, local government, and the private sector.

2.2.6 Archiving GHG Information

Nepal is currently working to maintain a centralized, secure, and comprehensive archive of GHG data to ensure long-term data integrity, transparency, and ease of verification. The archive will contain detailed records of emissions from each IPCC sector, including raw activity data, calculation sheets, emission factors used, and methodological documentation following the IPCC 2006 Guidelines. This archival system will ensure that all input data, intermediate calculations, and results are readily available for future review, recalculations, and verification audits. The GHG data archive will be managed by the Ministry of Forests and Environment (MoFE) and will be regularly updated with annual submissions from key sectors. Data storage will follow strict QA/QC protocols, with a digital backup system to prevent data loss.

2.3 Brief General Description of Methodologies and Data Processing

2.3.1 Use of 2006 IPCC Guidelines and It's Refinement in 2019

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories, supplemented by the 2019 Refinement, serve as the primary methodological framework for estimating GHG emissions. These guidelines provide a tiered approach, allowing for the use of default (Tier 1) emission factors where sector-specific data is unavailable, and more detailed (Tier 2 and Tier 3) methods where higher accuracy is required or where measured data exists.

Both sets of guidelines provide detailed instructions on how to calculate emissions based on activity data, such as production volumes, raw material usage, and chemical reactions occurring within industrial processes. The methodology also includes recommendations for selecting appropriate data sources, managing uncertainties, and conducting recalculations when new or better data becomes available. Nepal adheres to these guidelines to ensure consistency with international reporting standards, using the most accurate data and methodologies applicable to the national context.

2.3.2 Decision Tree and Good Practices Method

The decision tree approach outlined in the 2006 IPCC Guidelines assists in selecting the most appropriate tier for calculating emissions based on data availability and the significance of emission sources. Nepal primarily employs Tier 1 methodologies for all sectors, which rely on default emission factors provided by the IPCC and national-level activity data, such as production volumes from industries like cement, lime, and metal production.

In cases where more detailed data is available, the decision tree guides moving to higher tiers (Tier 2 or Tier 3), which incorporate country-specific emission factors or direct measurements to improve the accuracy of GHG estimates.

Good practices, as defined by the IPCC, are strictly followed to ensure transparency, consistency, comparability, completeness, and accuracy (TCCCA) in data collection and reporting. This includes maintaining clear documentation of all data sources, assumptions, and methods used in the inventory. Nepal ensures that all activity data and emission factors are transparently reported, with clear references to industrial surveys, national databases, and international sources. Consistency is maintained across time series, allowing for accurate trend analysis. Comparability with international reporting standards is ensured by adhering to IPCC guidelines, and efforts are made to minimize uncertainties through quality assurance (QA) and quality control (QC) procedures.

2.4 Description of QA/QC Plan and Implementation

Verification is a crucial step in creating accurate and reliable greenhouse gas (GHG) inventories in Nepal. It ensures that the inventory meets high standards of quality, including transparency, consistency, comparability, completeness, and accuracy. This verification process is designed to be practical, cost-effective, and part of an ongoing effort to continually improve the inventory.

Verification involves a series of activities and procedures implemented throughout the entire lifecycle of the GHG inventory, from planning and development to its final use. To achieve this, a Quality Control and Quality Assurance (QA/QC) Plan is established and followed.

The QA/QC Procedures are illustrated in Figure 2. All QA/QC activities are conducted under the responsibility of the Climate Change Coordinator within the Climate Change Management Division under the Ministry of Forest and Environment. These activities are carried out by Sectoral Experts who are responsible for developing the inventory, in collaboration with the national and international technical experts who are responsible for quality assurance.

The sectoral leads are responsible for the QA/QC of the activity data and GHG estimation at the sectoral level. Activity data is collected under the supervision of sectoral experts. QC of activity data is either done by a Sectoral expert or an assistant under the supervision of a Sectoral expert. The final set of activity data is reviewed by the sectoral expert for QA.

The Sectoral experts are responsible for the estimates of GHG and the QC of the estimates. The GHG estimates at the sectoral level are verified by using the IPCC inventory software, which further assures the quality of the inventory calculated. Following the QA at the sectoral level, the Inventory Team Leader, in collaboration with the sectoral experts, prepares the national GHG inventory along with the National Inventory Report (NIR).

The national GHG inventory and NIR are verified by external reviews for QA. The external reviewers are national and international experts (including experts from UNFCCC) who are not involved in the national GHG preparation process. Following the feedback from external reviewers, the final national inventory is prepared under the leadership of the Team Leader. The final stage of the QA/QC procedure is the final validation workshop, which is considered the final QA, organized by the Climate Change Management Division.

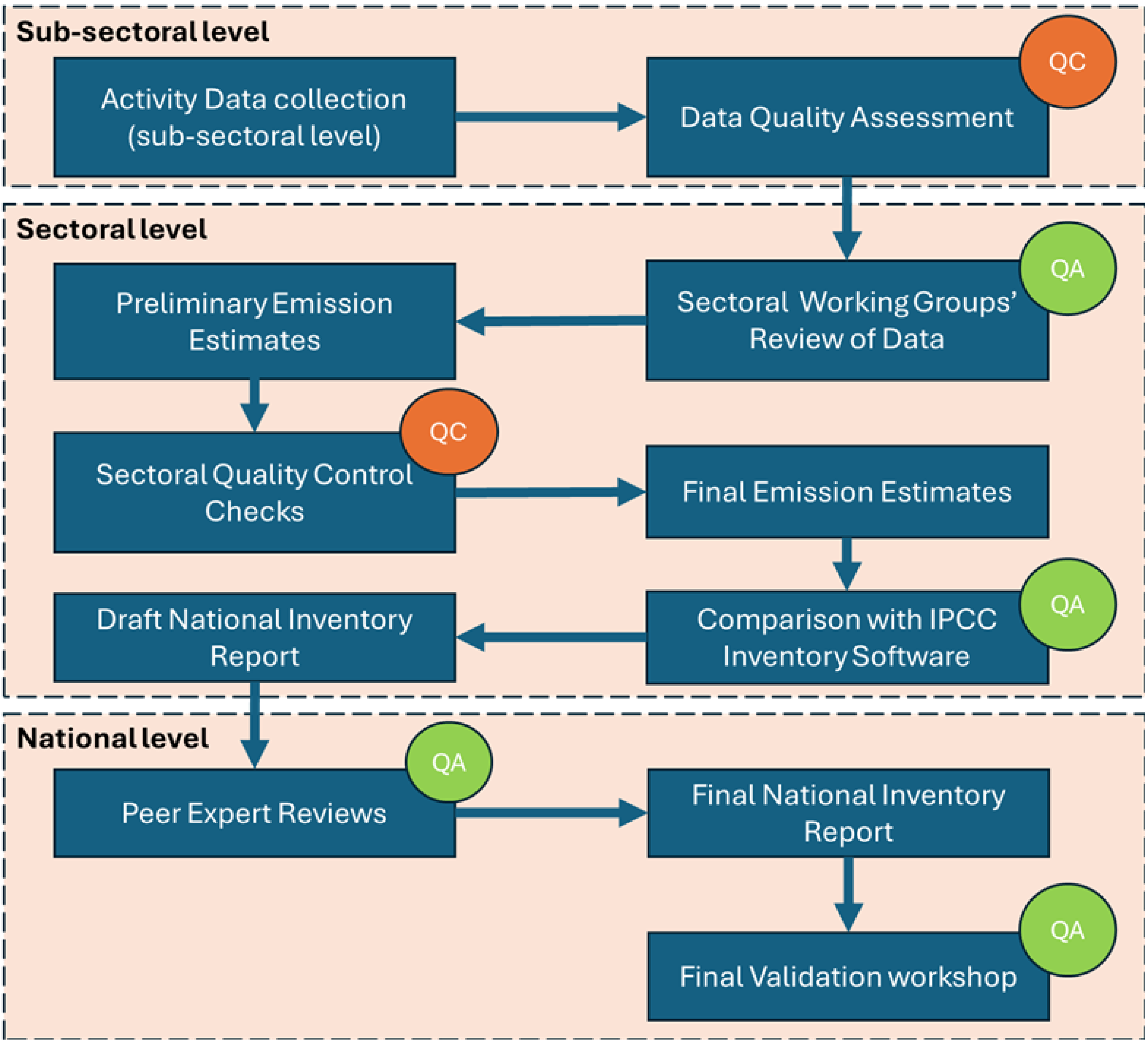


Figure 8: QA/QC procedures

Quality control procedures were conducted at different stages of GHG inventory preparation. The following quality control procedures were conducted for all sectors:

- Verification of the activity data received for mechanical errors.
- Verification of the entered data for mechanical errors.
- Verification of calculations to fill activity data gaps using mathematical methods.
- Verification of the entry of emission units, parameters, or conversion factors.
- Verification of greenhouse gas emission calculations.
- Verification of consistency of input and calculations in time series in changing method, emission factors/other parameters, or data.

- Verification of the correctness of entering formulas, calculations, etc., in modified worksheets according to national worksheet conditions.
- Verification of calculations in the development of national factors.
- Verification of emission source documentation (suppositions, assumptions, and criteria for selection of calculation methods, activity data, emission factors, and other multipliers).
- Verification of all references related to data and factors.
- Cross verification of data.

The inventory preparation process also includes quality assurance at various stages as shown in the QA/QC procedure diagram. The QA process includes the verification of the following at various stages:

- calculation method.
- activity data.
- factors and other parameters.
- emission data.
- Information on quality control conducted

2.5 Brief Description of Key Category of GHG Inventory

The national greenhouse gas (GHG) inventory utilized the IPCC Tier 1 methodology to analyse key categories, focusing on both the level and trend of emissions, as outlined in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. A key category is one that has a significant impact on the overall inventory, either through its absolute contribution to emissions or removals each year, or by influencing the trend of emissions over time. Identifying these categories is essential for prioritizing resources, refining estimation methodologies, and directing data collection efforts to improve the accuracy and completeness of the inventory.

Key source analysis identifies categories that cumulatively contribute 95% of total emissions, using two main criteria:

- Level Assessment: Categories that contribute significantly to the absolute level of emissions or removals in a particular year.
- Trend Assessment: Categories that have a substantial impact on the trend of emissions or removals over time, highlighting changes in emissions patterns.

The categories are ranked by their percentage contribution to total national emissions or trends, in descending order. This ranking enables the identification of both high-emission categories and those that exhibit rapid changes, facilitating targeted prioritization.

Key observations from the analysis include:

- Forest land remaining forest land (3.B.1.a) has shown a negative emission trend, indicating carbon sequestration. However, it still contributed 19.87% to the trend, reflecting the importance of sustainable forest management in mitigating GHG emissions.
- Settlements remaining settlements (3.B.5.a) also contributed significantly with a negative emission trend of 16.86% share.
- Enteric fermentation (3.A.1) remains a significant contributor to GHG emissions. Enteric fermentation accounted for 9.77% of the emissions trend, reflecting the impact of livestock on methane emissions.
- Moderate contributions were observed from cropland remaining cropland (3.B.2.a) and grassland remaining grassland (3.B.3.a), with 9.32% and 6.67% shares, respectively. These reflect the effects of agricultural intensification on CO_2 emissions.
- Cement production (2.A.1) has become a notable source of CO_2 emissions, contributing an

8.6% share to the trend. This reflects the rapid growth of industrial activities and infrastructure development.

- Fossil Fuels in Manufacturing: Emissions from manufacturing industries and construction using solid fuels (1.A.2) have increased, contributing 7.57% to the emissions trend. This highlights the growing reliance on fossil fuels in industrial energy consumption.
- Road transportation (1.A.3.b) has also seen a rise in emissions, contributing 4.04% to the trend. This indicates the increasing use of liquid fuels in the transportation sector, driven by urbanization and economic activity.
- The "Other Sectors - Biomass (Solid Fuels)" category (1.A.4) shows significant emissions, contributing 2.80% to the emissions trend. This indicates the ongoing reliance on traditional biomass for energy in rural regions.
- Rice cultivation (3.C.7) contributed moderately, with a 1.96% share, indicating the ongoing influence of agricultural practices on methane emissions.
- Solid waste disposal (4.A) and wastewater treatment and discharge (4.D) have contributed to GHG emissions, with 1.98% and 1.94% shares, respectively. These emissions are linked to urbanization and population growth, which have increased waste generation and the need for wastewater treatment.

The key category analysis highlights the continued dominance of agricultural activities in Nepal's GHG emissions, particularly from enteric fermentation and rice cultivation. Industrial growth, especially in cement production and manufacturing, has become a significant driver of CO_2 emissions. The reliance on traditional biomass and fossil fuels in rural and industrial sectors, respectively, remains a challenge. Additionally, emissions from transportation, waste management, and agricultural intensification are on the rise, reflecting broader economic and demographic changes. Sustainable practices in agriculture, industry, and waste management will be critical to mitigating future emissions.

The detailed results of the key source analysis, along with the associated calculations, are presented in Annex III. These findings offer a comprehensive overview of the key categories in the national GHG inventory and their contributions to overall emissions trends. This analysis will inform strategic interventions, optimize resource allocation, and enhance future inventory processes, supporting the development of effective climate policies.

2.6 General Uncertainty Assessment

Uncertainty assessments play a pivotal role in enhancing the accuracy and reliability of the national greenhouse gas (GHG) inventory. These assessments are designed to identify the most significant sources of uncertainty within the inventory, allowing for a focused approach to data collection and guiding the selection of more precise estimation methodologies. Such efforts aim to improve the robustness of reported emissions and removals and to build confidence in the inventory results.

Uncertainty evaluations were conducted for all sectors and categories included in the inventory, following the IPCC Tier 1 methodology. Calculations were performed using a 95% confidence interval to quantify the range of potential variations in reported values. The primary drivers of uncertainty in GHG emissions are attributed to the variability and reliability of two key components: activity data and emission factors. These factors are influenced by data quality, availability, and representativeness for the specific inventory conditions.

The combined uncertainty of the national GHG inventory was estimated for two key years: the base year 2012 and the end year 2022. The overall combined uncertainty was determined to be 78.371%. Among the categories assessed, the highest uncertainty was recorded for 3.C.5 - Indirect N2O Emissions from Managed Soils, at an exceptionally high 515.28%. This indicates substantial variability in either the activity data, emission factors, or both for this category. Conversely, the lowest combined uncertainty was observed for 1.A.3.a.i – International Aviation, 1.A.3.a.ii. – Domestic Aviation and 2.F.1.a – Refrigeration and Stationary Air Conditioning, at a much lower value of 5%.

The outcomes of these uncertainty assessments are crucial for identifying areas where targeted improvements can yield significant benefits. For categories that exert the greatest influence on overall inventory uncertainty, priority actions include the adoption of higher-tier GHG emission estimation methodologies, which are typically more detailed and precise. Additionally, efforts will focus on the refinement and enhancement of activity data, including increasing the frequency, accuracy, and geographic coverage of data collection.

The detailed uncertainty calculations, encompassing both the overall inventory and individual sectors, are documented in Annex IV. These results not only provide transparency in the reporting process but also serve as a roadmap for strategic improvements in future GHG inventories. By addressing the identified uncertainties systematically, the accuracy of national GHG estimates can be significantly improved, aligning with international best practices and reporting standards.

3

GHG Emissions and Removals

3.1 National Inventory for 2022

Nepal's total net GHG emissions amount to 38,211.96 Gg CO_2-eq, with the largest contributions from the energy sector (65.4%) and industrial processes and product use (IPPU), 12.6%. Emissions from agriculture, forestry, and other land use (AFOLU) make up to 9.4% and the waste sector contributes 12.6%. The energy sector, driven by fuel combustion, is the largest emitter, reflecting Nepal's growing reliance on fossil fuels. IPPU emissions primarily come from the mineral industry, driven by industrial growth. AFOLU is a mixed contributor, with high methane (CH_4) and nitrous oxide (N_2O) emissions from livestock and cropland, but it also offsets a large share of emissions through significant carbon dioxide (CO_2) removals from forests (20,021.96 Gg CO_2). The waste sector's emissions stem mainly from wastewater treatment and solid waste disposal, highlighting inefficiencies in waste management. While Nepal benefits from natural carbon sinks in its forestry sector, rising emissions from energy and industrial sectors point to the need for renewable energy adoption, sustainable land-use practices, and improved waste management. The overall emission from each sector is given in Table 6.

Table 6: National Inventory of GHGs in Nepal in 2022

Inventory Year: 2022	**Emissions (Gg)**				**Net GHG Emissions**
Categories	**Net CO_2**	**CH_4**	**N_2O**	**HFC**	**(Gg CO_2 -eq)**
Total National Emissions and Removals	**- 1,474.073**	**1,235.852**	**19.115**	**0.012848**	**38,211.96**
1 - Energy	13,567.620	383.423	2.682	-	25,014.290
1.A - Fuel Combustion Activities	13,567.620	383.423	2.682	-	25,014.290
1.A.1 - Energy Industries	0.023	0.000	0.000		0.023
1.A.2 - Manufacturing Industries and Construction	6,999.824	2.157	0.301		7,140.070
1.A.3 - Transport	4,629.203	0.861	0.410		4,761.971
1.A.4 - Other Sectors	1,938.570	380.405	1.971		13,112.227
2 - Industrial Processes and Product Use	4,794.891	-	-	0.012848	4,811.594
2.A - Mineral Industry	4,792.239	-	-	-	4,792.239
2.A.1 - Cement production	4,792.239				4,792.239
2.D - Non-Energy Products from Fuels and Solvent Use	2.652	-	-	-	2.652
2.D.1 - Lubricant Use	1.900				1.900
2.D.2 - Paraffin Wax Use	0.752				0.752
2.F - Product Uses as Substitutes for Ozone Depleting Substances	-	-	-	0.012848	16.703
2.F.1 - Refrigeration and Air Conditioning				0.012848	16.703
3 - Agriculture, Forestry, and Other Land Use	- 19,916.207	733.118	11.172	-	3,571.787
Inventory Year: 2022	**Emissions (Gg)**				**Net GHG Emissions**
Categories	**Net CO_2**	**CH_4**	**N_2O**	**HFC**	**(Gg CO_2 -eq)**
3.A - Livestock	-	649.999	1.976	-	18,723.500

3.A.1 - Enteric Fermentation		595.951			16,686.635
3.A.2 - Manure Management		54.048	1.976		2,036.865
3.B - Land	- 20,021.958	-	-	-	-20,021.958
3.B.1 - Forest land	- 18,072.100				-18,072.100
3.B.2 - Cropland	6,345.516				6,345.516
3.B.3 - Grassland	- 38.794				- 38.794
3.B.5 - Settlements	- 8,256.580				-8,256.580
3.C - Aggregate sources and non-CO_2 emissions sources on land	105.751	83.119	9.197	-	4,870.245
3.C.2 - Liming	0.531				0.531
3.C.3 - Urea application	105.220				105.220
3.C.4 - Direct N_2O Emissions from managed soils			6.314		1,673.181
3.C.5 - Indirect N_2O Emissions from managed soils			2.576		682.552
3.C.6 - Indirect N_2O Emissions from manure management			0.307		81.425
3.C.7 - Rice cultivation		83.119			2,327.337
4 - Waste	79.623	119.311	5.260	-	4,814.291
4. A - Solid Waste Disposal		48.682			1,363.106
4. B - Biological Treatment of Solid Waste		0.320	0.018		13.843
4. C - Incineration and Open Burning of Waste	79.623	1.590	0.024		130.390
4.D - Wastewater Treatment and Discharge		68.718	5.218		3,306.952

Figure 9 highlights that the highest GHG emissions are from energy combustion, largely due to the inefficient burning of wood and biomass in the residential sector, which contributes significantly to CH_4 emissions. Fossil fuel combustion and non-energy uses are the next major contributors to GHG emissions. When emissions and removals from land use are excluded, the agriculture and livestock sector become the largest contributor, followed by the energy sector. This shift shows the substantial impact of methane and nitrous oxide emissions from livestock and agricultural practices. Both charts emphasize that the energy sector should be the primary focus for GHG emission reduction strategies, as it offers more viable opportunities for abatement compared to agriculture or waste. Nepal's abundant potential for clean, renewable energy further reinforces the need to transition from traditional biomass and fossil fuels to sustainable energy sources.

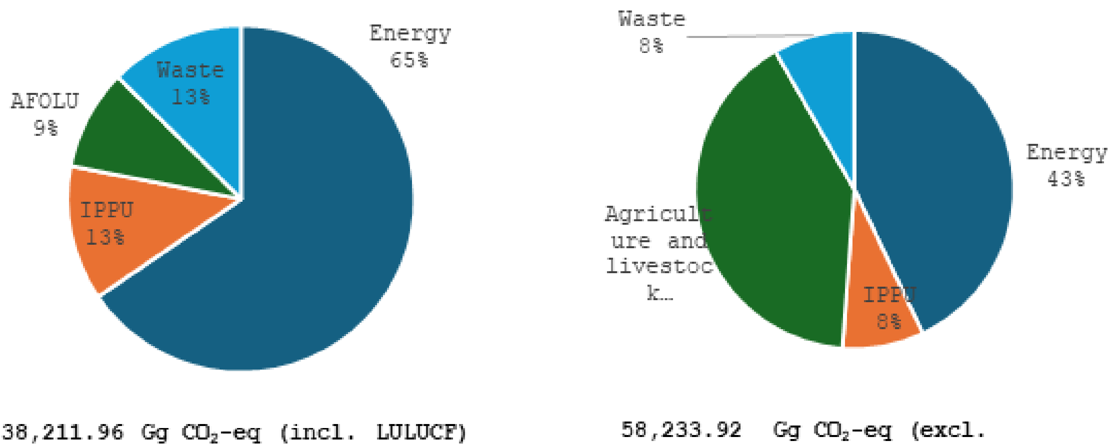


Figure 9: Shares of GHG emissions from different sectors in 2022

3.2 Trends in Greenhouse Gas Emissions

Figure 10 shows the growth trend of GHG emissions in Nepal from 1994 to 2022. Nepal has experienced a steady growth in GHG emissions, with an average annual increase of 3.26% since 2011, as reported in the Third National Communication (MoFE, 2021). However, recalculations suggest a slightly higher growth rate of 4.2% per annum, using 2011 as the reference year. The energy sector remains the largest contributor, with emissions rising due to increased fuel combustion. This is driven by economic growth, population expansion, and enhanced access to modern fuels like LPG, which has reduced reliance on biomass. Biomass combustion still contributes significantly to CH_4 emissions in rural areas. The Industrial Processes and Product Use (IPPU) sector has seen the fastest growth, attributed to the expansion of industrial activities such as cement production and improved data availability.

The Agriculture, Forestry, and Other Land Use (AFOLU) sector exhibits mixed trends, with a rise in emission removals due to effective land use and forest management policies. Livestock and agricultural practices remain key sources of CH_4 and N_2O emissions in this sector. The waste sector has experienced a decline in emissions, likely due to improved waste management practices and greater efficiency in wastewater treatment. Overall, the energy sector continues to dominate as the primary source of emissions, underscoring the need for mitigation strategies focusing on transitioning to clean, renewable energy sources. At the same time, IPPU and waste require targeted interventions to curb their increasing or persistent emissions.

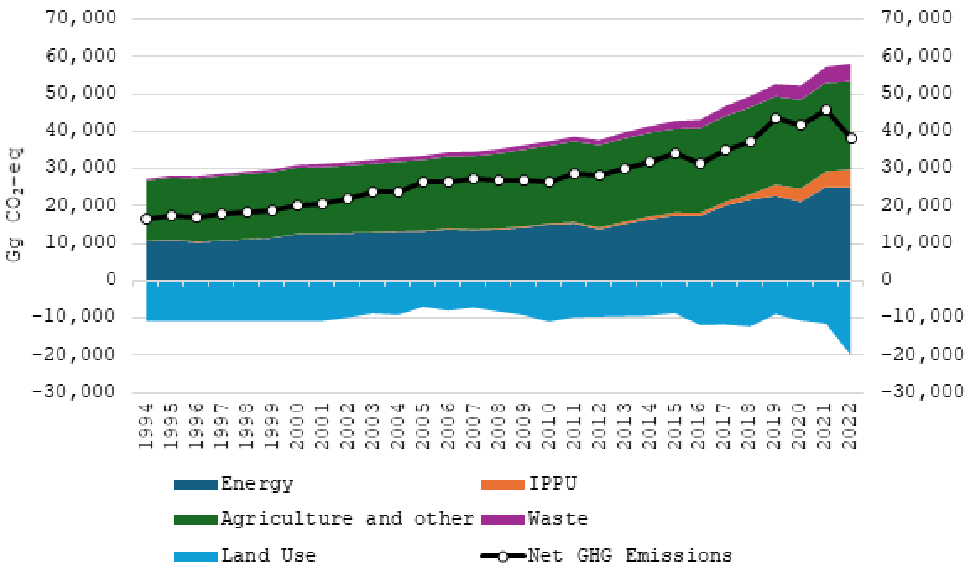


Figure 10: GHG emissions trend by sectors in Nepal from 1994 to 2022

Figure 11 illustrates the trend of Nepal's national greenhouse gas (GHG) emissions from 1994 to 2022, broken down by CO_2, CH_4, and N_2O emissions, along with CO_2 removals from land use. Over the years, CO_2 emissions, primarily from the energy and industrial sectors, have steadily increased, which is mainly due to the increase in the combustion of fossil fuels. CH_4 emissions remain the largest contributor to total GHG emissions, largely due to agricultural activities such as livestock rearing and rice cultivation, as well as biomass combustion. N_2O emissions have shown a moderate increase over time, driven by fertilizer use in agriculture. Notably, CO_2 removals from land use have grown significantly, reflecting Nepal's successful forest conservation and reforestation initiatives. Net GHG emissions show a steady upward trend, particularly after 2011, as industrialization, urbanization, and energy consumption intensified. However, the increasing carbon sequestration from land use has helped moderate the growth in net emissions, especially in recent years. This highlights the critical role of land use management as a carbon sink and emphasizes the need for targeted mitigation strategies to address rising CO_2 and CH_4 emissions from the energy and agriculture sectors.

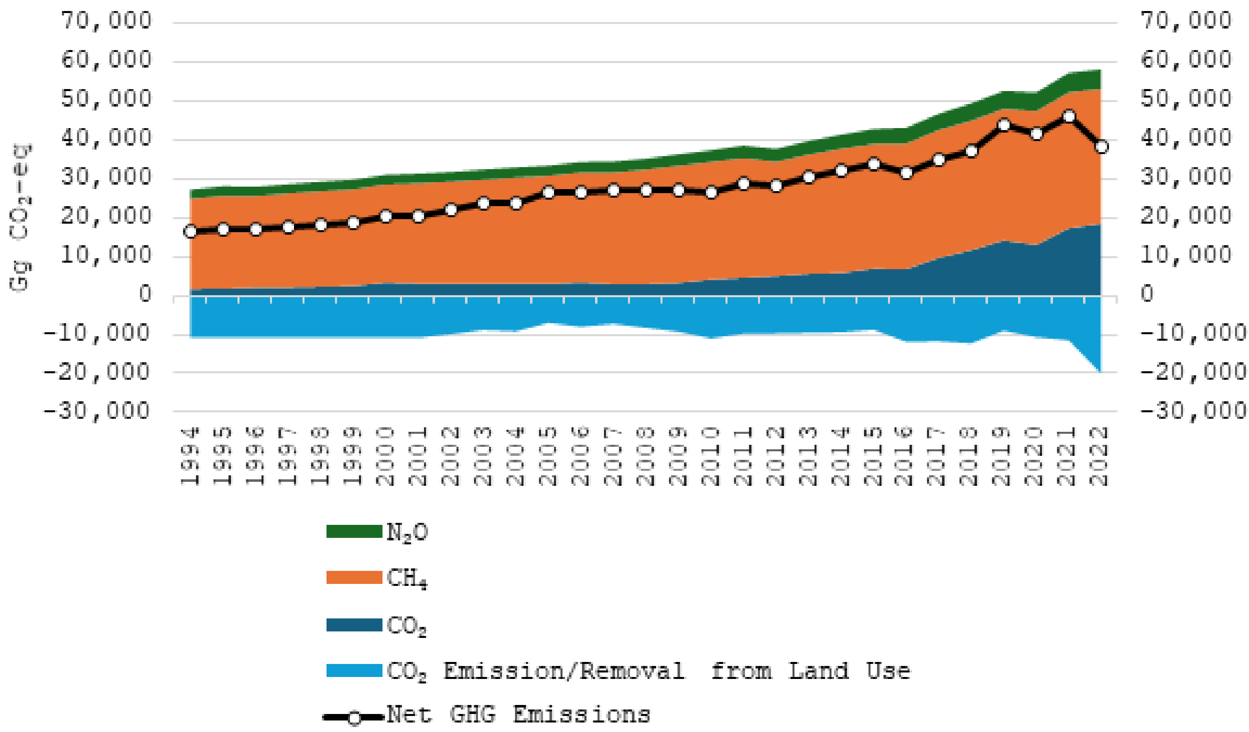


Figure 11: GHG emissions trend by gases in Nepal from 1994 to 2022

3.3 Energy

Nepal's energy sector is characterized by a mix of traditional, commercial, and alternative resources. Traditional energy sources, such as biomass fuels, including fuel wood, agricultural residue, and animal dung, still fulfill much of the country's vast energy demand. Commercial energy sources consist mainly of fossil fuels and electricity, while alternative options include micro-hydro, solar, wind power, biogas, and briquettes. Despite the growth in petroleum consumption over the past decade, which has significantly contributed to increased greenhouse gas (GHG) emissions, biomass remains a dominant energy source. To achieve sustainable development, Nepal must gradually reduce its reliance on biomass and imported fuels by promoting renewable energy.

GHG emissions from the energy sector arise from both stationary sources, such as electricity generation, manufacturing, and residential activities, and mobile sources like road transport and aviation. Following the IPCC Guidelines (2006), emissions from energy-related activities, listed in Table 7. The table reports various sectors and subsectors within the energy industry.

Table 7: IPCC emission categories in energy sector relating to Nepal

Category Code	Category Name	Remarks
1	Energy	
1 A	Fuel Combustion Activities	
1 A 1	Energy Industries	
1 A 1 a	Main Activity Electricity and Heat Production	
1 A 1 a i	Electricity Generation	Thermal Plants operated by Nepal Electricity Authority
1 A 2	Manufacturing Industries and Construction	

1 A 2 a	Iron and Steel	
1 A 2 b	Non-Ferrous Metals	
1 A 2 c	Chemicals	
1 A 2 d	Pulp, Paper and Print	
1 A 2 e	Food Processing, Beverages and Tobacco	Nepal Standard Industrial Classification (NSIC) are as per ISIC 4th revision (2008),
1 A 2 f	Non-Metallic Minerals	IPCC categories are as per ISIC 3rd revision (1989)
1 A 2 g	Transport Equipment	The categories are grouped as per classification given by (WECS, 2021a, 2021b, 2022a, 2024)
1 A 2 h	Machinery	
1 A 2 i	Mining (excluding fuels) and Quarrying	
1 A 2 j	Wood and Wood Products	
1 A 2 k	Construction	
1 A 2 l	Textile and Leather	
1 A 2 m	Non-specified Industry:	
1 A 3	Transport	
1 A 3 a	Civil Aviation	
1 A 3 a i	International Aviation (International Bunkers)	Based on fuel sold by Nepal Oil Corporation
1 A 3 a ii	Domestic Aviation	Based on fuel sold by Nepal Oil Corporation
1 A 3 b	Road Transportation	Based on fuel consumption in sector
1 A 3 b i	Cars	Aggregate data
1 A 3 b ii	Light-duty Trucks	Based on the number of vehicles registered in category published by Department of Transport Management (DoTM, 2019; MoF, 2023)
1 A 3 b iii	Heavy-duty Trucks and Buses	
1 A 3 b iv	Motorcycles	
1 A 3 e	Other Transportation	
1 A 3 e ii	Off-road	Tractors/Trailers
1 A 4	Other Sectors	
1 A 4 a	Commercial/Institutional	Based on fuel consumption in sector
1 A 4 b	Residential	Based on fuel consumption in sector
1 A 4 c	Agriculture/Forestry/Fish Farms	
1 A 4 c i	Stationary	Based on fuel consumption in sector
1 A 4 c ii	Off-road Vehicles and Other Machinery	Based on fuel consumption in sector
1 A 4 c iii		Fishing (mobile combustion)
1 A 5	Non-Specified	

3.4 Methodology

3.4.1 Reference Approach

This top-down approach of the GHG emission estimation is based on the total energy supply of the fuels. The total fuel usage and hence the emissions by this method are generally higher than the real consumption due to possible unreported losses, stock changes, or inaccuracies in accounting for energy trade/fuel movements.

3.4.1.1 Activity data

For the reference approach, the overall energy supply data are collected from Trade statistics (DoC, 1970) Nepal Oil Corporation (NOC, 2024) and Economic Survey Reports by the Ministry of Finance (MoF, 2023). The following data are being obtained from each source.

Institution	Energy Data	Remarks
Nepal Oil Corporation	Diesel, Gasoline, Kerosene, Jet Kerosene, LPG, Residual Fuel Oil,	Sales Data
Department of Customs	Coal, Residual Fuel Oil	Import Data
Ministry of Finance	Total Energy Consumption data by fuel groupings	Published in the annual Economic Survey reports

3.4.1.2 Apparent consumption of fuels

The apparent consumption of the fuel was estimated by using the formula

Apparent consumption

= Production + Imports – Exports – International bunkers – Stock change

Among the fuels, the given fuels are produced indigenously, and/or imported.

The production data for wood/wood waste and other primary solid biomass for use in energy are not well recorded. Therefore, it is assumed that the quantity consumed is equal to the quantity produced/extracted. Similarly, accurate data for Coal imports and production are also not well recorded. Therefore, wherever the data are missing, it is assumed that the import of coal is equal to the consumption and the production of coal is zero, in case data is unavailable.

3.4.1.3 Sectoral approach

For the sectoral approach, which is a bottom-up approach, each sector and its activities were identified. The main source of such data is the Water and Energy Commission Secretariat, the National Statistics Office (the then Central Bureau of Statistics), the Department of Industries, the Department of Transportation, and other reports from government agencies.

For the estimation of emissions from each sector, the general equation given was used

$$\text{Emissions}_{s,g,f} = \text{Activity}_{s,f} \times \text{Emission Factor}_{g,f}$$

Where,

$\text{Activity}_{s,f}$ = the total Fuel f consumed by combustion in the Sector s ($_{TJ}$)

$\text{Emissions}_{s,g,f}$ = emission of given GHG g by specific type of fuel f in the specific sector s (kg)

$\text{Emission Factor}_{g,f}$ = default emission factor of a given GHG g by fuel f (kg /TJ). For CO_2, it includes the carbon oxidation factor, assumed to be 1

Therefore, the total emission would be

$$\text{Total Emissions}_{GHG} = \sum \sum \text{Emissions}_{GHG,Sector,Fuel}$$

The results of both approaches were compared and are discussed in a later section related to the comparison of the reference and sectoral approaches.

The total activity data was based on the energy consumption reports by WECS. Fuel-specific data is available for certain years and is provided in the annex. The missing data was derived by appropriate interpolation and splicing methods. The verification for such estimation was done by comparing supply and consumption data of fuels given by the annual Economic Survey reports by the Ministry of Finance. The data is presented in Annex V.IV. The detailed methodology and assumptions are given in the sections below.

3.4.1.3.1 Energy generation:

The energy generation plants in Nepal are primarily thermal generators. The two main thermal plants in Nepal are operated by Nepal Electricity Authority (NEA) – Duhabi multifuel plant, which uses fuel oil, and Hetauda Thermal Plant, which uses diesel oil. Although there are decentralized generators being used by manufacturing industries and commercial institutions, there is no ample data for an exact approximation. Therefore, the use of fuel was included within each sector, and not in the Electricity Generation category. The activity data for electricity generation by NEA is given in Annex V.V

Estimation methodology

Categorization

Category Code	Category Name	Remarks
1	Energy Sector Fuel	--
1 A	Fuel Combustion Activities	--
1 A 1	Energy Industries	--
1 A 1 a	Main Activity Electricity and Heat Production	--
1 A 1 a i	Electricity Generation	Thermal Plants operated by Nepal Electricity Authority
1A1aii	Combined Heat and Power Generation (CHP)	- NE (Two 3 MW of CHP installed in Sugar mills, which are in operation only for a couple of years. Not enough data gathered.)

NE: Not Estimated

Data sources

Data	Source	Remarks
Generation	Nepal Electricity Authority (NEA-GD, 2023, 2020)	
Fuel Economy	Literature (Pokhrel, 2013; THT, 2012)	Cross-validated with Nepal Electricity Authority during KII

3.4.1.3.2 Manufacturing Industries and Construction

The manufacturing sector in Nepal is in growing stride, and thus the energy consumption is also growing accordingly. In totality, the manufacturing sector has been the second-largest consumer of energy (WECS, 2023, 2010). However, the quantity of energy has increased by a huge amount in the past decade. The major fuels used by manufacturing industries are fossil fuels, thus it has been the largest emission sector in the energy category past year 2000 (MoPE, 2017; MoSTE, 2014).

The data on the number of industries and their output in the form of economic value are available in the industrial survey by the National Statistical Office. However, detailed data such as the specific production in each year and fuel consumption by each type are not readily available. Therefore, the activity data for Manufacturing Industries and Construction be estimated using data from the registration data from

Department of Industries (DOI), number, output and energy intensities from National Statistics Office (NSO), and energy consumptions from Water and Energy Commission Secretariat (WECS). Relevant data from previous communication reports and credible literature sources were used.

Note: The IPCC 2006 categories are based on the third revision of the International Standard Industrial Classification (ISIC) (UN, 1989), while the Nepal Standard Industrial Classification (NSIC)(CBS, 2019) is updated based on the Fourth revision of ISIC (UN-DESA, 2008). The categories have been adjusted accordingly to update respective groupings. The old and new categorizations are given in Annex V.VI. The manufacturing industries are then categorized based on data availability from DOI, CBS, NSO and WECS. The construction and mining sector energy has not been estimated due to lack of historical data on their activity and energy consumption.

Table 8: Manufacturing Industries sub categorization

Category		Remarks
1 A 2 a	Iron and Steel	Includes: 1A2b, 1A2g, 1A2h
1 A 2 b	Non-Ferrous Metals	IE: 1A2a
1 A 2 c	Chemicals	IE: 1A2m
1 A 2 d	Pulp, Paper and Print	IE: 1A2j
1 A 2 e	Food Processing, Beverages and Tobacco	
1 A 2 f	Non-Metallic Minerals	
1 A 2 g	Transport Equipment	IE: 1A2a
1 A 2 h	Machinery	IE: 1A2a
1 A 2 i	Mining (excluding fuels) and Quarrying	NE
1 A 2 j	Wood and Wood Products	Includes: 1A2d
1 A 2 k	Construction	NE
1 A 2 l	Textile and Leather	
1 A 2 m	Non-specified Industry:	Includes: 1A2c

IE: Included Elsewhere; NE: Not Estimated

Data Sources

Data	Source	Remarks
Industrial Categories	(CBS, 2019; UN-DESA, 2008; UN, 1989; WECS, 2021a, 2021b, 2022a, 2024)	Industrial categories have been updated as per 4th revision of ISIC and lates NSIC. The subcategories have been grouped as per data availability based on WECS reports.
Number of Industries	(CBS, 2022a; DoI, 2024)	
Total Energy consumption	(MoF, 2019a, 2024; WECS, 1996, 2010, 2022b, 2023)	
Industrial energy consumption	(WECS, 2024, 2023, 2022a, 2021a, 2021b, 2014, 2010, 1996, 1994)	Provincial level energy consumption and fuel wise energy share from provincial reports National level from synopsis reports

3.4.1.3.3 Transportation

The transportation sector is the next most energy-consuming sector after the manufacturing industries (WECS, 2023) and the second-most emissive sector from energy use (MoPE, 2017). This is because the transportation sector is also highly dependent on fossil fuels only.

In Nepal, the Department of Transport Management used to maintain the national vehicle registration data. However, after federal restructuring, the agencies responsible for doing so are the provincial authorities. The vehicle registered till date is given in Annex V.VII.

The data on the number of operational vehicles is not available. Therefore, it was derived using indirect approach (Malla, 2014). The distance traveled and fuel economy foreach type of vehicle were estimated from transport research by CBS (CBS, 2014a) and provincial energy reports (WECS, 2024, 2022a, 2021c) to calculate the activity data.

Vehicle Categorization

IPCC Category	Nepal Registration Category	Remarks
1.A.3.a.i International Aviation		IE: International Bunkers
1.A.3.a.ii Domestic Aviation		
1.A.3.b.i Cars	Car/Jeep/Vans Tempo	
1.A.3.b.ii Light Duty trucks	Pickups	
1.A.3.b.iii Heavy Duty trucks and buses	Bus Minibus/minitruck Microbus	
1.A.3.b.iv Motorcycles	Motorcycles	
1.A.3.e.ii Off-road (Other vehicles)	Tractors/Power tillers	Other than used in Agriculture [category 1.A.4.c.ii]

NE: Not Estimated, IE: Included Elsewhere

Data Sources

Data	Source	Remarks
Vehicle Registration number	(DoTM, 2019; MoF, 2024)	
Operation Factor	(CBS, 2014a; Malla, 2014)	
Annual distance travelled (km)	(CBS, 2014a; WECS, 2021a, 2021b, 2022a, 2024)	
Fuel economy (km/liter)	(WECS, 2024, 2022a, 2021a, 2021b)	
Fuel/energy consumed	(WECS, 2024, 2023, 2022a, 2021a, 2021b, 2014, 2013, 2010, 1996, 1994)	

3.4.1.3.4 Other sectors

The other sectors category comprises commercial/institutional, residential, and agricultural energy use. The commercial/institutional sector is a service-oriented sector and most of the fossil fuels are consumed in Accommodation and Food Service Activities (ISIC and NSIC Division 55 and 56). In the residential sector, the majority of the fuel consumed is still biomass (WECS, 2023). Meanwhile, the agriculture sector is still largely dependent on non-mechanized techniques of agriculture.

Data Sources

Data	Source	Remarks
Residential sector energy Consumption	(WECS, 2023, 2022b, 2013, 2010, 1996, 1994)	Emission factor for biomass stoves (IPCC, 2006, Volume 2 Chapter 2 Table 2.9) and (MoPE, 2017)
Commercial sector energy consumption		
Agriculture sector energy consumption		1.A.4.c.i - Stationary = Irrigation and Threshers 1.A.4.c.ii - Off-road vehicles and other machinery = Tillers and other farm machineries

The main activity data relating to other sectors was obtained from WECS reports (WECS, 2023, 2022b, 2013) (Annex V.III).

3.4.2 Trend of Emissions in Energy sector

The trend of emissions since the first communication report to 2022 is as shown in Figure 12. It indicates that he GHG emissions in Nepal has been growing at the rate of 3.18% per annum between 1994 and 2022. The type of emissions shows that CH_4 was the highest emissions in 1994, which accounts for 81%, 14% being CO_2 and rest as nitrous oxide of total GHG equivalent emissions. While coming to 2022, the mix changes to 54% CO2, 43% CH_4 and 3% N2O. This change in mix of emission gases is due to change in fuel used. In the past, biomass use was significantly contributing to methane emissions. While with advancements, the use of fossil fuels has risen sharply, contributing to higher CO_2 emissions.

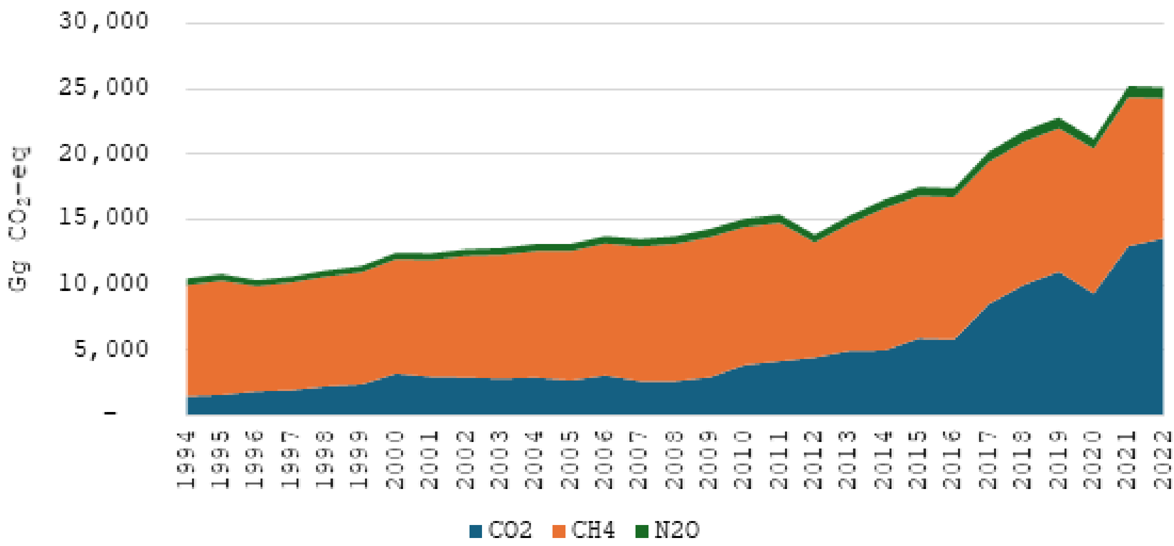


Figure 12: GHG emissions from Energy sector from 1994-2022

The Figure 13 illustrates the greenhouse gas (GHG) emissions from the energy sector across various sub-sectors between 1994 and 2022. Over this period, total emissions have shown a steady upward trend, with a sharp increase starting around 2015. The residential sector consistently dominates emissions, as indicated by its significant share, highlighting its reliance on high-emission energy sources. The transport sector has seen a notable rise in emissions since 2015, reflecting the growing impact of expanding transportation infrastructure. Similarly, emissions from manufacturing industries have grown steadily, contributing significantly to the overall increase. While electricity generation has a relatively smaller share, and it shows a declining trend, particularly after 2015, due to increased availability of clean electricity generation plants. In contrast, the commercial and agriculture sectors contribute minimally to total emissions. The overall trend reflects increasing energy demands across residential, industrial, and transportation sectors, driven by population growth, urbanization, and industrialization.

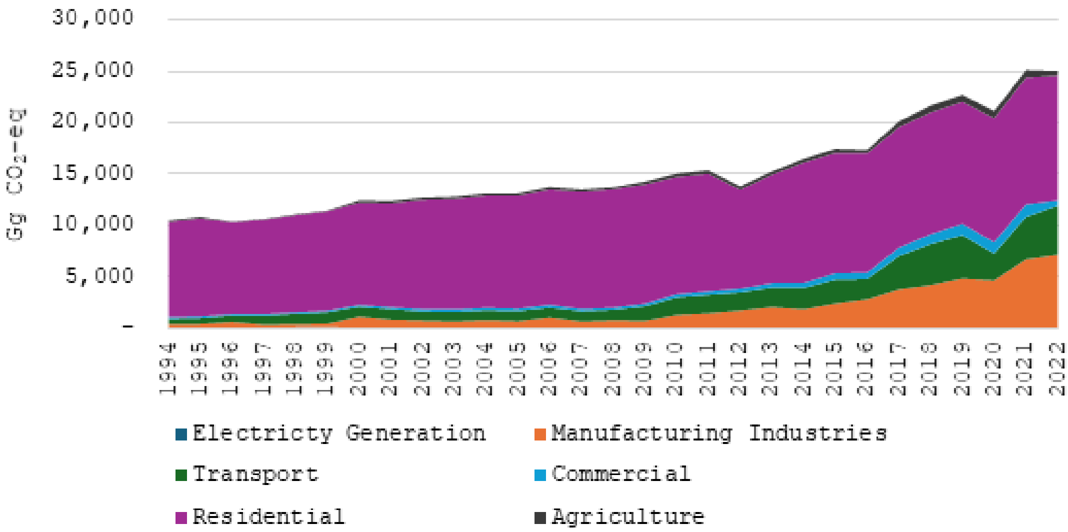


Figure 13: GHG emissions in energy sector by sub sectors from 1994 to 2022

3.4.3 Recalculation of emissions 1994-2011

The GHG inventory for the Initial National Communication (INC), Second National Communication (SNC), and Third National Communication (TNC) have been reevaluated. The major changes identified during the calculations are the revised and/or new emission factors in the IPCC 2006 guidelines, compared to those in the IPCC 1996 guidelines. Additionally, the later version provides a more detailed list of energy types. Furthermore, while the INC and SNC use the global warming potential (GWP) factor from the Second Assessment Report (SAR), the TNC uses the GWP factors from the Fourth Assessment Report (AR4). Moreover, the methane emission factor for wood stoves and other biomass stoves has been taken as the Tier 2 default factor from the TNC.

For recalculation purposes, all the emission factors have been updated as per IPCC 2006 including methane emission factor for residential wood and biomass stoves. In addition to that, the GWP factor has been taken as per the Fifth Assessment Report (AR5). The GWP for each assessment report is given in Annex I.I. The recalculations of the GHG inventory gave out results as shown in Figure 14.

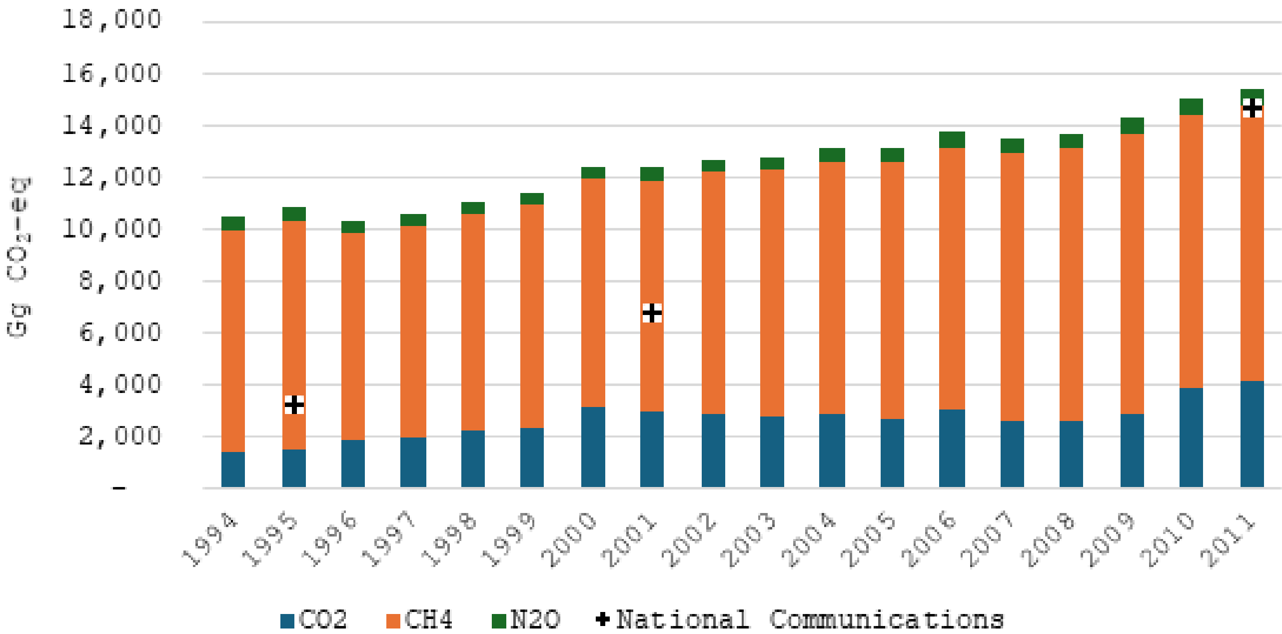


Figure 14: GHG emissions from Energy sector during 1994-2011

It can be observed that there are differences in total emissions in previously calculated GHG inventory and recalculations. The main factor of these differences being the updated emission factors and the GWP factors.

3.4.4 GHG Emissions Inventory of 2012-2022

Figure 15 illustrates the GHG emissions from the year 2012 to 2022. In recent years, CO_2 has accounted for the largest share of emissions due to increased fossil fuel consumption and a corresponding decline usage of biomass. Noticeable drops in emissions occurred during the periods 2015–2016 and 2019–2020. The decline in the earlier period is attributed to reduced energy and fuel use resulting from the political situation, while the later drop is due to the impact of the global COVID-19 pandemic.

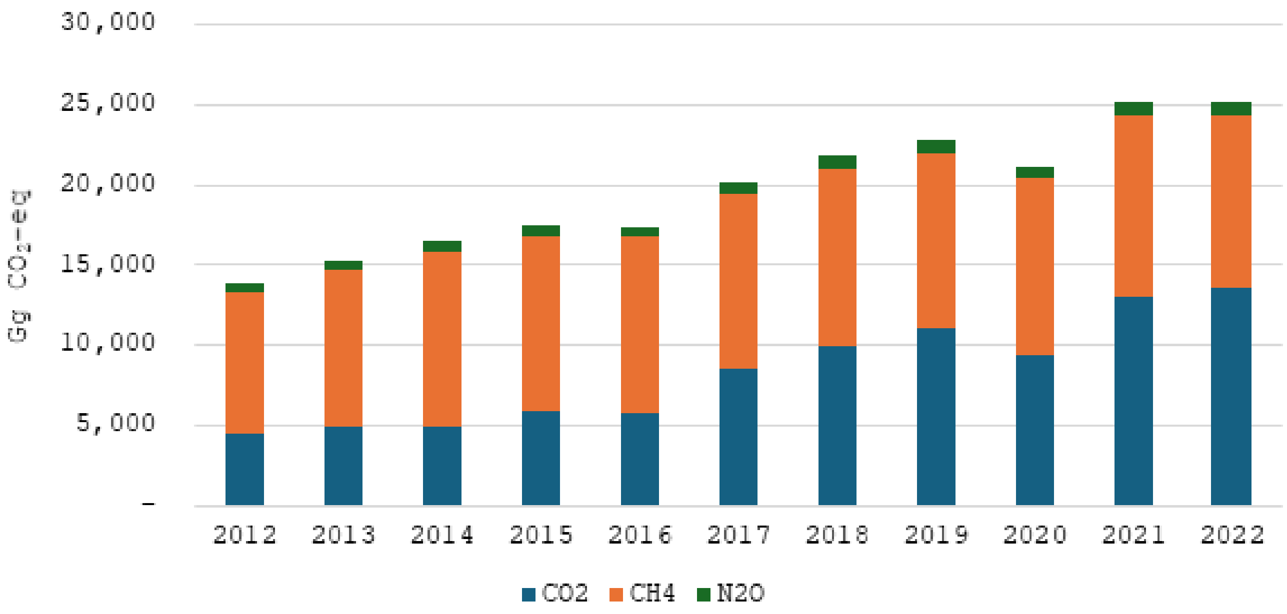


Figure 15: GHG emissions from Energy sector from 2012 – 2022

3.4.5 Sub Sectoral Emissions

Total GHG emissions have historically been dominated by methane emissions from biomass burning, particularly where biomass is widely used for cooking and heating in residential and commercials sectors. However, this sector's contribution is gradually decreasing due to shift to modern fuels like LPG, electricity, and renewables and have reached 52% in 2022 from 75% in 2012. As economies grow, energy consumption patterns are shifting towards more efficient, cleaner energy sources, reducing reliance on biomass and lowering methane emissions. At the same time, the manufacturing sector is seeing a rapid increase in emissions driven by higher production and consumption and thus their emission has reached 29% from 12 % in 2012. Similarly, emissions from the transport sector are rising, fueled by both population growth and economic development and thus reaching 19% in 2022 from 13% in 2012.

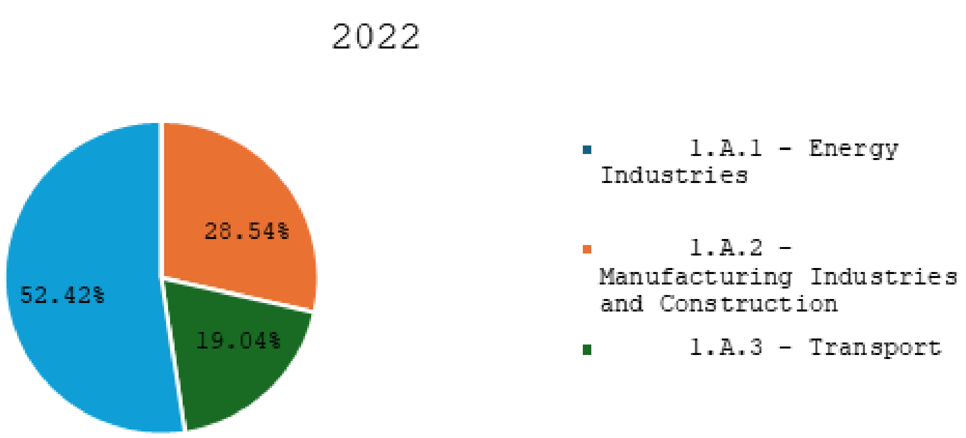


Figure 16: Subsector emission for year 2022

Table 9: GHG emissions from Energy sector in 2022

	CO_2	CH_4	N_2O	Total
Categories	**Gg CO_2-eq**	**Gg CO_2-eq**	**Gg CO_2-eq**	**Gg CO_2-eq**
1 - Energy	13,567.62	10,735.85	710.82	25,014.29
1.A - Fuel Combustion Activities	13,567.62	10,735.85	710.82	25,014.29
1.A.1 - Energy Industries	0.02	0.00	0.00	0.02
1.A.1.a - Main Activity Electricity and Heat Production	0.02	0.00	0.00	0.02
1.A.1.a.i - Electricity Generation	0.02	0.00	0.00	0.02
1.A.2 - Manufacturing Industries and Construction	6,999.82	60.40	79.84	7,140.06
7,140.07				
1.A.2.a - Iron and Steel	775.37	1.51	2.37	779.25
1.A.2.e - Food Processing, Beverages and Tobacco	346.61	8.95	11.52	367.08
1.A.2.f - Non-Metallic Minerals	4,643.46	18.36	25.36	4,687.17
1.A.2.j - Wood and wood products	98.61	19.04	24.10	141.75
1.A.2. - Textile and Leather	157.12	7.47	9.53	174.12
1.A.2.m - Non-specified Industry	978.66	5.07	6.96	990.70
1.A.3 - Transport	4,629.20	24.10	108.67	4,761.97
4,761.97				
1.A.3.a - Civil Aviation	159.16	0.03	1.18	160.37
1.A.3.a.i - International Aviation (International Bunkers) (1)	-	-	-	-
1.A.3.a.ii - Domestic Aviation	159.16	0.03	1.18	160.37
1.A.3.b - Road Transportation	3,930.51	23.22	52.31	4,006.03
1.A.3.b.i - Cars	675.20	6.16	8.67	690.03
1.A.3.b.ii - Light-duty trucks	224.34	0.33	3.13	227.80
1.A.3.b.iii - Heavy-duty trucks and buses	1,997.20	2.94	27.86	2,028.00
1.A.3.b.iv - Motorcycles	1,033.77	13.78	12.65	1,060.20
1.A.3.e - Other Transportation	539.54	0.85	55.18	595.57
1.A.3.e.ii - Off-road	539.54	0.85	55.18	595.57
1.A.4 - Other Sectors	1,938.57	10,651.34	522.31	13,112.22
3,112.23				
1.A.4.a - Commercial/Institutional	352.60	167.01	21.35	540.95
1.A.4.b - Residential	1,205.14	10,483.38	477.95	12,166.47
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	380.84	0.95	23.02	404.81
1.A.4.c.i - Stationary	159.13	0.60	0.34	160.07
1.A.4.c.ii - Off-road Vehicles and Other Machinery	221.71	0.35	22.68	244.74
Categories				
Memo Items (3)	-	-	-	-
International Bunkers	230.83	0.05	1.71	232.59
1.A.3.a.i - International Aviation (International Bunkers) (1)	230.83	0.05	1.71	232.59
CO2 from Biomass Combustion	46,128.97	-	-	46,128.97

(2024 estimations. Extracted from IPCC GHG Inventory software 2.93)

Table 10: Other emissions from Energy sector in 2022

Branch	Sulfur Dioxide	Nitrogen Oxides	NMVOC	Carbon Monoxide
Energy Industries	0.00	0.00	0.00	-
Electricity Generation	0.00	0.00	0.00	-
Manufacturing Industries	59.58	25.14	20.84	34.52
Iron and Steel	5.32	3.56	0.47	6.20
Food Beverage and Tobacco	1.41	3.06	3.18	10.16
Non-metallic minerals	46.08	9.52	6.01	0.47
Wood and wood products and others	0.22	2.72	6.80	1.58
Textile and Leather	0.38	1.87	2.66	3.55
Other Industries	6.18	4.41	1.73	12.56
Transport	7.89	25.29	32.80	95.97
Civil Aviation	0.04	-	-	0.15
Road Transportation	7.85	25.29	32.80	95.82
Other Sector	9.14	23.18	210.43	103.45
Commercial Institutional	0.59	2.16	6.04	46.78
Residential	7.61	17.98	204.10	54.78
Agriculture	0.94	3.04	0.29	1.89
Total	76.61	73.61	264.07	233.93

3.4.5.1 Electricity Generation

The electricity generation in Nepal is almost all from clean energy sources. The only major fossil fuel-using plants are also not in use in the current year. They only operate for yearly maintenance. Therefore, their emission has become negligible as seen from Table 10.

3.4.5.2 Manufacturing Industries and Construction

This category has grown significantly and is now the second-largest emitter of greenhouse gases in Nepal, contributing approximately 29% of the total GHG emissions in 2022, which totals 7,140 Gg CO_2-eq emissions. The largest share of emissions within this category comes from non-metallic minerals, primarily the brick, cement, and clay pottery industries in Nepal. The extensive use of coal and oil for thermal energy in these industries is the main source of emissions. Non-metallic minerals industries account for 66% of the total emissions within the manufacturing sector. The second largest emitter in this category is the “non-specified industries” subcategory, which contributes 14% of the total manufacturing emissions. This subcategory encompasses various small industries. Additionally, the iron and steel industry is a significant emitter, contributing about 11% to the total emissions within the manufacturing category. Together, these industries highlight the key sources of emissions in Nepal’s industrial sector.

3.4.5.3 Transport

The transport sector accounted for 4,762 Gg of GHG emissions - nearly 19% of total GHG emissions from fuel combustion in 2022. Like the manufacturing sector, the transport sector is expanding, primarily due to the growing economy and size of the vehicle fleet. The increase in transport activities can be attributed to several factors, including economic growth, population expansion, greater access to transportation, and rising economic capacity, which enables more people to afford vehicle ownership. According to the IPCC classification, the highest emissions within the transport sector come from heavy vehicles such as buses, minibuses, mini trucks, and trucks, which together contribute 43% of emissions in the sector. This represents about 8% of total emissions from fuel combustion. Following this, emissions from motorcycles, which have been increasing rapidly in number, and from cars, jeeps, and vans also contribute significantly to the overall transport emissions. This trend highlights the growing impact of personal and commercial vehicle use on GHG emissions as economies develop and urbanize.

3.4.5.4 Other Sector

The "other" sector is the largest emitter of GHGs from fuel combustion, contributing approximately 13,112 Gg of emissions. The largest share of these emissions comes from the residential sector, primarily due to the use of biomass stoves. While CO_2 emissions from biomass burning are not included in the total GHG emissions, CH_4 emissions from biomass stoves, particularly in developing regions, are notably high, as reported by the IPCC (2006). As a result, the CO_2-equivalent GHG emissions from the residential sector alone account for about 49% of emissions from fuel combustion. In contrast, emissions from the commercial sector and agricultural activities contribute much smaller portions, with their share generally limited to single-digit percentages.

3.4.5.5 Emissions from biomass combustion

This category estimates the carbon dioxide (CO_2) emissions from the combustion of solid biomass. These emissions are not included in the total greenhouse gas (GHG) emissions but are provided separately for informational purposes. The primary source of emissions in this category is the burning of fuelwood, which is commonly used for cooking and heating in households, especially in rural areas. In addition to fuelwood, emissions also come from the burning of other biomass materials, such as agricultural residues and animal waste. According to the estimated data, in 2022, the total CO_2 emissions from biomass combustion in Nepal amounted to 46,128.97 Gg.

3.4.5.6 International bunker

Total GHG emissions do not include CO_2 emissions from international bunkers. In Nepal, the only international bunker is related to aviation. In 2022, GHG emissions from the international aviation bunker amounted to 232.59 Gg CO_2-eq.

3.4.6 Comparison of Reference and Sectoral approaches to assess CO_2 emissions from Fuel Combustion

In line with the IPCC Guidelines (2006), both the Reference and Sectoral approaches were applied to estimate CO_2 emissions from fuel combustion activities, serving as a cross-check for total emissions. Table 6 presents the total CO_2 emissions for each approach and the percentage difference between them. The differences between the Reference and Sectoral approaches are inconsistent, indicating variability in calculation methods and data accuracy. The largest deviation in the calculated values occurred for the historical year 1995, with subsequent years showing negative differences. Some key reasons for these discrepancies include:

- Informal energy sources and unaccounted energy consumption, which may lead to discrepancies.
- Lack of data on the non-energy use of fuels.
- Differences in energy accounting methods, with the net calorific value of fuels significantly influencing estimates. Accurate classification of fuels and their properties, as well as specific usage, should be determined through research.
- Including fuels used for non-energy purposes, such as cooking coal, which increases the total energy usage.
- Incomplete, underestimated, or misreported data in the sectoral approach, causing energy consumption to appear higher than the energy supply data suggests.
- Failure to properly reflect energy efficiency improvements in the sectoral approach, leading to overestimations of energy consumption for a given output.

Table 11 Comparison of CO2 emissions from Fuel Combustion

Year	Reference Approach	Sectoral Approach	Difference %
1994	1,752.38	1,470.16	19.20
1995	1,908.03	1,569.68	21.56
1996	2,184.76	1,851.78	17.98
1997	2,245.26	1,953.10	14.96
1998	2,347.84	2,226.95	5.43
1999	2,416.23	2,381.34	1.47
2000	3,206.44	3,202.88	0.11
2001	2,880.19	2,963.82	-2.82
2002	2,803.26	2,920.49	-4.01
2003	2,681.09	2,812.43	-4.67
2004	2,569.25	2,904.06	-11.53
2005	2,569.25	2,695.37	-4.68
2006	2,859.82	3,064.09	-6.67
2007	2,508.05	2,629.55	-4.62
2008	2,560.99	2,631.80	-2.69
2009	2,770.59	2,925.70	-5.30
2010	3,787.56	3,869.82	-2.13
2011	4,032.05	4,148.83	-2.81

Year	Reference Approach	Sectoral Approach	Difference %
2012	3,757.40	4,437.37	-15.32
2013	4,251.86	4,937.38	-13.88
2014	4,655.34	4,978.83	-6.50
2015	5,860.39	5,922.31	-1.05
2016	5,213.59	5,822.67	-10.46
2017	7,846.78	8,548.19	-8.21
2018	11,317.54	10,006.65	13.10
2019	9,752.84	11,013.06	-11.44
2020	9,752.84	9,348.14	4.33
2021	12,062.99	12,979.40	-7.06
2022	12,375.70	13,567.62	-8.79

3.4.7 Uncertainty assessment and time series consistency

The activity data uncertainty is assumed to be ±5% (as for countries with a less developed system of national statistics), except for biomass data (IPCC Guidelines 2006). The biomass data uncertainty is assumed to be about ±50%, since data on biomass as a fuel is not so reliable. The uncertainty ranges are derived based on the lower and upper limits of emission factors given in Table 2.2, 2.3, 2.4,2.5, 2.9, 3.2.1 and 3.2.2 of IPCC guidelines for each subsector. Since the ranges are different for each fuel within the same category, the lowest percentage value for lower range and highest percentage value for higher range are taken, within each category. The uncertainty ranges are given in Annex V.XII. For uncertainty trend analysis, the base year has been taken as 2012, and the end year is 2022.

For maintaining consistency in the GHG estimation in the energy sector, the structure of sectors and subsectors has been made consistent so that there is the same level of disaggregation throughout 29 years (1994 to 2022). The following assumption on activity data has been made to ensure Time Series Consistency.

- The activity data of manufacturing industries has been calibrated using the value addition of each sub-sector, thus representing the level of activity in each period.
- The residential sector has not been divided into urban and rural areas, as there was an abrupt change in urban population, as per the definition by the government.
- The disaggregation in the transport sector has followed the registration format by the Department of Transport Management.
- In the absence of details of vehicles (and emission standards), the fuel economy and emission factors have been assumed to be the same.
- The newly added "Construction and mining sector", which has been reported very recently, has not been included in the analysis, but its energy consumption and thus emissions are estimated for other industries and other transport subsectors.

- Other assumptions are also mentioned in each sectoral section and the methodologies.

The same emission factors have been used to estimate the emissions throughout the year, and it is assumed that the net calorific values of fuels also remain the same. In addition to that, the range of uncertainty has also been assumed to be the same for all the years.

Category-specific QA/QC and verifications

Tier 1 QA/QC procedures were implemented for Category 1.A Energy Sector.

The QA/QC procedures followed the general principles and QA/QC plan guidelines.

The verification process included the following:

- Ensuring proper documentation of energy-related emission sources.
- Checking data for transcription and mechanical errors.
- Validating the accuracy of formulas and units of measurement across the time series.
- Confirming the consistent application of emission factors for all subcategories.
- Verifying references to data sources and emission factors in the IPCC Inventory Software.
- Evaluating the selection of methodological tiers based on data availability and sectoral relevance.
- Reviewing trends for logical consistency throughout the time series.

The final activity data were cross-checked using the latest IPCC Inventory Software to ensure consistency with results from the national inventory calculation files, specifically developed for Nepal's energy sector.

3.4.8.1 Comparison of national estimates of CO_2 related to fuel combustion with data from the International Energy Agency

The accuracy of estimated CO_2 emissions from activities related to fuel combustion obtained in current inventory both from reference and sectoral approach has been compared with the similar data from International Energy Agency (IEA). The results show that they differ (in absolute terms) from IEA by 11% at an average for reference approach and 7% for sectoral approach (the median difference being 9 and 5% respectively).

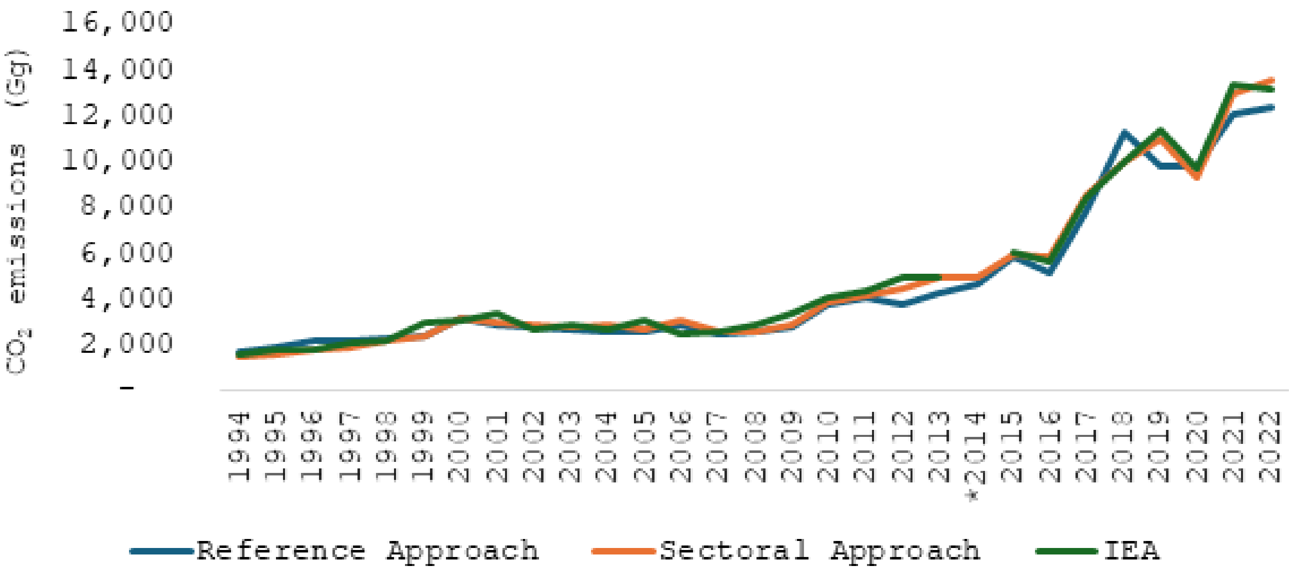


Figure 17 Current inventory results with IEA data on CO2 emissions from Fuel Combustion Activities

(IEA, 2024) and Estimations

*2014 value of IEA has been adjusted to 2015 to make the trend comparable. This discrepancy should have arisen due to a difference in reporting for the fiscal year. In Nepal, the fiscal year generally begins on July 16 and ends on July 15 of the next year. A similar trend is in energy data.

3.4.9 Category-specific planned improvements

3.4.9.1 Challenges/Limitations and Necessities

Category	Challenges/Limitations	Necessity
Updated Data and Data Availability	- Lack of historical data for recalculation and trend analysis. - Limited centralized database for systematic updates. - Inconsistent data	- Accurate and updated data is essential for precise GHG estimation and tracking trends like energy mix changes, efficiency improvement, emission characteristics and so on.
Data Disaggregation Suitable for IPCC Guidelines	- Aggregated data does not align with IPCC guidelines (e.g., Vehicle registration data for certain categories are lumped into a single group, making it difficult to assess emissions from specific vehicle types. Energy consumption data for industrial sectors are aggregated, preventing detailed analysis of individual subsectors.).	- Disaggregated data enables compliance with IPCC standards and improves sector-specific emission calculations.
Research to Establish National Emission Factors	- Limited information on national-specific emission factors - Inconsistent fuel properties due to lack of standardization (For example in case of coal) - Validation and authenticity of available scientific data	- National emission factors improve accuracy as they reflect local fuel characteristics and conditions. - The available scientific data is to be validated by in-line agencies for their use and authenticity
Subsector-Level Studies	- Detailed bottom-up studies require significant time, effort, and dedicated resources. - Limited human resources and expertise for such studies.	- Bottom-up approaches enable accurate estimations by capturing subsector-level variations, improving overall inventory quality.
Inter-Agency Collaboration	- Lack of coordination among agencies. - Inconsistent data standards across sectors. - Absence of a unified data-sharing platform.	- Collaboration ensures high-quality data collection, sharing, and consistency in GHG inventory preparation.
Capacity Building and Training	- Shortage of trained personnel with an understanding of GHG inventories. - Limited awareness of IPCC guidelines among stakeholders.	- Skilled professionals are critical for accurate data collection, analysis, and reporting.

3.4.9.2 Recommendations and agencies

Category	Recommended Actions	Agencies
Updated Data and Data Availability	- Develop a centralized database for sectoral and historical data. - Encourage regular contributions from the public and private sectors. - Set guidelines for accurate data reporting.	WECS, NSO, MoEWRI, MoICS, MoPIT, NOC, DoC

Data Disaggregation Suitable for IPCC Guidelines	- Revise data collection frameworks to ensure disaggregation by sector/subsector. - Train agencies on IPCC requirements. - Implement digital tools for precise data collection.	WECS, MoEWRI, MoICS, MoPIT
Research to Establish National Emission Factors	- Conduct research to determine fuel properties and emission factors. - Repeat studies periodically to capture changes. - Collaborate with universities and research institutions for validation.	WECS, NAST, Uni
Subsector-Level Studies	- Assign a dedicated team under an authoritative agency. - Conduct progressive analyses by sector/subsector over time. - Integrate findings into developing the national GHG inventory.	WECS, MoEWRI, MoICS, MoPIT, MoALD
Inter-Agency Collaboration	- Establish an inter-agency task force for coordination. - Develop a unified data-sharing platform managed by the National Statistics Office. - Conduct regular capacity-building programs for agencies. - Conduct collaborative research studies for estimation of GHG in respective sectors with one agency being MoFE.	NSO, MoFE, WECS, MoEWRI, MoICS, MoPIT, MoALD
Capacity Building and Training	- Organize training programs for stakeholders on IPCC guidelines. - Partner with international organizations and donor agencies for technical support and capacity building.	MoFE

DoC: Department of Customs; MoALD: Ministry of Agriculture and Livestock Development; MoEWRI: Ministry of Energy, Water Resources and Irrigation; MoFE: Ministry of Forest and Environment; MoICS: Ministry of Industry, Commerce and Supplies; MoPIT: Ministry of Physical Infrastructure and Transport; NSO: National Statistics Office; NAST: Nepal Academy of Science and Technology; NOC: Nepal Oil Corporation; Uni: Universities and Academic Research Laboratories; WECS: Water and Energy Commission Secretariat

Some subsector-wise recommendations for the energy sector that can be made as an initial step are as follows:

Sector	**Activities**
Manufacturing Industries and Construction	• Update the data of the actual number of industries running and their operational capacity • Take inventory of industries by type of product, technology, the use, and fuel they use • Take inventory of in-house electricity generation that is for self-use and/or sale. • Update on the basis of WECS provincial energy reports integration • Determined specific emission factors
Transport	• Take inventory of actual operational vehicles • Categorize vehicles on a more granular basis (by type of vehicle, type of registration, type of engine emission standards) • Take sample survey on operation (vehicle kilometer, capacity used, fuel economy etc., emission) • Determined specific emission factors
Commercial/ Institutional	• Update on basis of WECS provincial energy reports integration • Determined specific emission factors

Residential	• Update on basis of WECS provincial energy reports integration • Inventory of type of fuel based cookstoves, heating and other appliances used • Determined specific emission factors
Agriculture	• Take inventory of machinery used for agriculture (number, capacity, operation etc.) • Update on basis of WECS provincial energy reports integration
Energy supply	• Identify the gaps in current information recoding system • Update energy recording structure and system • Harmonize the data specific to energy and fuels • Setup disaggregated energy information recording system • Conduct research on fuel quality and parameters

3.5 Industrial Processes and Product Use (IPPU)

The IPPU sector (IPCC Sector 2) contributes to greenhouse gas (GHG) emissions through chemical or physical transformations of raw materials into products. Unlike energy-sector emissions from fuel combustion, IPPU emissions stem from process-related activities. Examples include CO_2 released during cement and lime production, as well as emissions from iron, steel, ammonia, and aluminum manufacturing.

The sector also includes emissions from GHG containing products, such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6), used in refrigeration and industrial applications. Non-energy uses of fossil fuels, like petrochemical products and lubricants, also contribute to emissions.

In Nepal, significant IPPU emissions come from cement production, which is a rapidly growing industry. Additional emissions arise from non-methane volatile organic compounds (NMVOCs) in food, beverage, pulp, and paper production, as well as imported refrigerators, such as HFCs and PFCs. While these refrigerants do not deplete the ozone layer, they have high global warming potential.

Emissions from non-energy fossil fuel uses, such as lubricants and paraffin waxes, are also notable. Nepal relies on imports for these products, with data sourced from customs and reports. Effective monitoring and sustainable management are critical as industrialization increases.

The Table 12 shows IPPU categories in Nepal considered in this inventory.

Table 12: Categories of Nepal's IPPU sector

Category Code	**Category Name**	**Action**
2A	Mineral Industry	
2A1	Cement Production	✓
2A2	Lime Production	IE
2B	Chemical Industry	NO
2C	Metal Industry	
2C1	Iron and Steel Production	✓
2D	Non-Energy Products from Fuels and Solvent Use	
2D1	2D1 Lubricant Use	✓
2D2	2D2 Paraffin Wax Use	✓
2E	2E Electronics Industry	NO
2F	2F Product Uses as Substitutes for Ozone Depleting Substances	
2F1a	2F1a Refrigeration and Stationary Air Conditioning	✓
2G	2G Other Product Manufacture and Use	
2G3a	2G3a Medical Applications	NE
2H	2H Other	

2H1	2H1 Pulp and Paper Industry	✓
2H2	2H2 Food and Beverages Industry	✓

NO- Not Occurring, NE- Not Estimated, IE- Included Elsewhere, ✓- Estimated

The Third National Communications (TNC) of Nepal estimated the emissions in Nepal for the base year 2011 in the following categories:

- Cement production
- Iron and steel production
- Product uses as substitutes for ozone depleting substances
- N_2O from product uses
- Non-energy products from fuels and solvent use
- Paper production

The TNC used 2006 IPPC Guidelines to estimate the GHG inventory.

3.5.1 Methodology

The emissions from the IPPU sector in Nepal is estimated following the 2006 IPCC National GHG Inventory Guidelines. The 2006 Guidelines include Tier 1 Approach, using default emissions factors provided by the IPCC based on global averages for industrial processes, and Tier 2/3 Approach (when applicable), in cases where more detailed activity data is available, country-specific emission factors or more refined process-level data can be used. Table 13 summarizes the methods and data required in different sub-categories of the IPPU sector. In the preparation of Nepal's National GHG Inventory, the Tier 1 method will be applied for the IPPU sector, as we lack detailed activity data and country-specific emission factors.

GHG emissions are calculated for each IPPU source category by multiplying the corresponding activity data by the relevant emission factors in MS Excel and also in IPCC Inventory Software v2.95. Depending on reporting requirements, emissions are disaggregated by specific pollutants (e.g., CO_2, CH_4, N_2O) or aggregated into total CO_2 equivalent emissions. The activity data for various industries is obtained from the government documents such as annual reports and journals of the Ministry of Industry, Commerce and Supplies, the Department of Industry, the Department of Mines and Geology, the Department of Customs, the Nepal Rastra Bank, and the National Statistics Office. A collection of data quantifying the level of activity for each identified IPPU source category includes production data (e.g., tonnes of cement produced), consumption data (e.g., amount of limestone used), and other relevant data.

Table 13: IPPU categories and method used

Category	Subcategory	Gases	Method	Required Data	Data Source
2A. Mineral Industry	2A1. Cement Production	CO_2, SO_2	T1	Clinker production data, cement production data, import and export data of clinker	Ministry of Industry Commerce and Supplies, Ministry of Finance, Department of Industry, Department of Customs, Nepal Rastra Bank, Third National Communication
2C. Metal Industry	2C1. Iron and Steel Production	NMVOC, NO_2, SO_2, CO	T1	National iron and steel production data	Ministry of Industry, Commerce and Supplies, Department of Industry, Nepal Rastra Bank

2D. Non-Energy Products from Fuels and Solvent Use	2D1. Lubricant Use	CO2	T1	National data for non-energy uses of lubricants	Department of Customs
	2D2. Paraffin Wax Use	CO2	T1	National data for non-energy uses of paraffin waxes	Department of Customs
2F. Product Uses as Substitutes for Ozone Depletion Substances	2F1a. Refrigeration and Air Conditioning	HFC-134a	T1	National import data of refrigerants	Department of Customs
2H. Others	2H1. Pulp and Paper Industry	NMVOC	T1	National pulp and paper production data	Ministry of Industry, Commerce and Supplies, Department of Industry, Nepal Rastra Bank
	2H2. Food and Beverages Industry	NMVOC	T2	National food and beverage production data	Ministry of Industry, Commerce and Supplies, Department of Industry, Nepal Rastra Bank

To facilitate aggregate reporting of GHG values, expressed as carbon dioxide equivalents (CO_2-eq), the global warming potentials (GWPs) values provided in the IPCC AR5 (temporal horizon 100 years) were used (see Annex I.I).

3.5.2 Activity data

Data collection for the IPPU sector followed a detailed and structured approach, involving direct data requests from the Ministry of Industry, Commerce, and Supplies, the Department of Industries, the Department of Mines and Geology, the Department of Customs, Nepal Rastra Bank, supplemented by national statistics and surveys. The inventory requires industries involved in cement, lime and iron and steel, pulp and paper, and food and beverage production to report detailed activity data, including production volumes, raw material usage, and process-specific emission rates. For sources such as HFCs used in refrigeration and air conditioning, lubricants, and paraffin wax, data on import, consumption, and leakage rates were collected.

3.5.2.1 2A1. Cement Industry

The activity data for national cement production in Nepal was sourced from various institutions, including the Ministry of Finance (MoF), the Third National Communication (TNC), and the Nepal Rastra Bank (NRB), as detailed in Annex VI.I. Cement production data for 1994 to 2007, extracted from the Economic Survey Reports published by the MOF and referenced in the TNC, lack specific information on national clinker production and clinker imports. Without this data, GHG emissions are likely to be overestimated.

For 2010 and 2011, data from the Nepal Energy Efficiency Programme (NEEP), referenced in the TNC, includes cement production only, limestone-based industries, allowing for a more accurate estimation of GHG emissions within Nepal. Data for 2015 to 2019, derived from NRB reports, includes total cement production, clinker production, and clinker import figures, aligning with clinker import data from the Department of Customs.

Due to the lack of continuous data from a single source, information from various references was combined to develop a comprehensive dataset. Missing values for the periods 2008-2009 and 2012–2014 were estimated using linear interpolation, and for the period 2020-2022, activity data were estimated by applying the average annual growth rate of cement production, derived from national clinker data spanning 1994 to 2019. This approach ensures a consistent and accurate dataset for examining national cement production trends.

3.5.2.2 2A2. Lime Production

Activity data for national limestone production in Nepal was obtained from the Department of Mines and Geology and the National Statistics Office, covering the years 2003–2022. Over 50% of the limestone appears to be used for clinker production, which has been accounted for under the cement production subcategory for GHG emissions. However, the specific industrial usage of the remaining limestone and the actual quantity of lime production are unknown.

Due to the absence of data on lime production after accounting for clinker production, this subcategory has been marked as "Not Estimated," despite the activity occurring in Nepal. This approach ensures a consistent and comprehensive dataset for further analysis.

3.5.2.3 2C1. Iron and Steel Production

Activity data for national iron and steel production in Nepal was obtained from the Nepal Rastra Bank (NRB), the Ministry of Finance (MoF), and the Third National Communication (TNC). In Nepal, the production of iron and steel primarily relies on imported sponge iron as a raw material to manufacture various steel products. Additionally, some factories utilize scrap iron or import ingots and billets to produce different metallic products. In all these processes, there is no transformation of the material's inherent properties, meaning no significant greenhouse gas (GHG) emissions are generated from industrial processes. However, certain emissions, such as NMVOC, CO, SO_2, and NO_2, are released due to the presence of various chemicals involved in the production processes. As a result, only these specific emissions are accounted for in this inventory, as they represent the primary sources of air pollutants associated with iron and steel production in the country.

3.5.2.4 2D1. Lubricant Use

The activity data for lubricant consumption in Nepal was collected from the Department of Customs' annual Foreign Trade Statistics (FTS) report, recorded in kilograms (kg). For use in the IPCC inventory software, the data was converted to terajoules (TJ). Data was available for the years 2008–2010 and 2014–2022. To address the missing data for the years 2011–2013, linear interpolation was applied, resulting in a complete and consistent dataset for analysis.

3.5.2.5 2D2. Paraffin Wax Use

The activity data for paraffin consumption in Nepal was collected from the Department of Customs' annual Foreign Trade Statistics (FTS) report, recorded in kilograms (kg). For use in the IPCC inventory software, the data was converted to terajoules (TJ). Data was available for the years 2007 and 2012–2022. To address the missing data for the years 2008-2011, linear interpolation was applied, resulting in a complete and consistent dataset for analysis.

3.5.2.6 2F1. Refrigeration and Air Conditioning

The activity data for HFC use in Nepal was collected from the Department of Customs' annual Foreign Trade Statistics (FTS) report. This data was recorded as an integrated quantity of PFC and HFC mixtures. However, the IPCC inventory software requires data for each refrigerant individually. Due to the lack of specific data on individual refrigerants, we estimated the quantity of HFC-134a using the aggregated data. While this approach may lead to an overestimation of HFC emissions, it was necessary to provide at least one calculated value for the inventory, as HFCs were previously calculated in the Third National Communication (TNC).

3.5.2.7 2G3. N2O from product use

The activity data for N_2O use in Nepal was sourced from the Export-Import Data Bank Version 7.1, published by the Government of India, Ministry of Commerce & Industry, Department of Commerce, as referenced in the Third National Communication (TNC) report. Since the data could not be obtained from Nepal's annual Foreign Trade Statistics (FTS) report, this category has been marked as "Not Estimated," although it is occurring.

3.5.2.8 2H1. Pulp and Paper Industry

The activity data for national pulp and paper production in Nepal was collected from the Nepal Rastra Bank (NRB), the Ministry of Finance (MOF), and the Third National Communication (TNC). Data for the years 1994–2008 were sourced from NRB, MOF, and TNC, while data for 2011–2022 were obtained from NRB. To address the data gap for the years 2009–2010, linear interpolation was applied, resulting in a complete and consistent dataset for analysis.

3.5.2.9 2H2. Food and Beverages Industry

The activity data for the national production of biscuit, sugar, animal feed, beer, and liquor in Nepal were collected from the Nepal Rastra Bank (NRB) and the Ministry of Finance (MoF). To address the gaps in the dataset, linear interpolation was applied, ensuring a complete and consistent dataset for analysis.

3.5.3 Emission factors

The emission factors and other relevant parameters, along with the supporting documentation and technical references, were obtained from the IPCC Emission Factor Database (EFDB) 2007 and the EMEP-EEA (2016) guidelines. The EFDB 2007 contains a comprehensive set of default emission factors, which are used to estimate the amount of greenhouse gases emitted during various industrial and natural processes. These factors are crucial for calculating emissions in the context of national inventories and reporting requirements.

The EMEP-EEA (2016) guidelines provide additional technical references and methodologies for emission estimation. Both sources are widely recognized for providing standardized, reliable data to support emissions calculations and ensure consistency across different reporting and regulatory frameworks. These databases and guidelines help in deriving accurate emission estimates and contribute to the transparency and credibility of national greenhouse gas inventories.

Table 14: IPPU Emission factors by subcategories

IPPU Sub-category	CO_2	SO_2	NO_2	CO	NMVOC	Carbon Content	EF from Installed Base	Source
2A1 Cement Production	0.52t CO_2/t cement produced	0.3Kg SO_2/t cement produced						2006 IPCC Guidelines
2C1 Iron and Steel Production		45g SO_2/t steel produced	40g NO_2/t steel produced	1g CO/t steel produced	30g NMVOC/ steel produced			2006 IPCC Guidelines
2D1 Lubricant Use						20tC/TJ of Lubricant Use		2006 IPCC Guidelines
2D2 Paraffin Wax Use						20tC/TJ of Lubricant Use		2006 IPCC Guidelines

2F1a Refrigeration and Air Conditioning							15%	2006 IPCC Guidelines
2H1 Pulp and Paper Industry					2 kg NMVOC/t dried pulp			EMEP/EEA Guidebook 2023
2H2 Food and Beverages Industry					1 Kg NMVOCs/t biscuit produced			EMEP/EEA Guidebook 2023
					10 Kg NMVOCs/t sugar produced			EMEP/EEA Guidebook 2023
					1 Kg NMVOCs/ t animal feed produced			EMEP/EEA Guidebook 2023
					2 Kg NMVOCs/t beer produced			EMEP/EEA Guidebook 2023
					2 Kg NMVOCs/t liquor produced			EMEP/EEA Guidebook 2023

3.5.4 Trend of Emission in IPPU Sector

The chart presented in Figure 18 visualizes the progression of GHG emissions within Nepal's IPPU sector over a span of nearly three decades, from 1994 to 2022. It reveals a significant and continuous upward trend in emissions, particularly after 2010. This trend aligns with the expansion of industrial activities in Nepal, highlighting the growing importance of the IPPU sector in the national emissions profile.

The chart underscores carbon dioxide (CO_2) as the dominant GHG emitted by the IPPU sector, primarily driven by industrial processes such as cement production. Emissions of hydrofluorocarbons (HFCs), specifically HFC-134a, began to appear in the data from 2014 onwards, reflecting the increasing use of refrigerants in various industrial applications. However, emissions of nitrous oxide (N_2O) and other HFCs could not be accounted for due to the lack of specific activity data on individual compounds, indicating gaps in data collection and reporting. Between 1994 and 2009, emissions from the IPPU sector remained relatively low and stable, likely reflecting limited industrial development and production activities during this period. A notable surge in GHG emissions is observed from 2010 onwards, coinciding with the rapid growth of Nepal's industrial base. This increase is attributed to expanded cement production, the adoption of energy-intensive processes, and the rising use of industrial chemicals and materials. By 2022, CO_2 emissions from the IPPU sector reached an estimated 4794.89 Gg CO_2-eq, marking a substantial escalation compared to earlier years. Similarly, HFC-134a emissions, though relatively minor, showed a steady increase, reaching 16.703 Gg CO_2-eq in 2022.

The industrial expansion driving these emissions is also a critical factor in Nepal's economic development, presenting a dual challenge of balancing growth with sustainability. The consistent and significant rise in GHG emissions from the IPPU sector, as demonstrated in the chart, signals a pressing need for proactive measures. These should focus on improving efficiency, adopting cleaner technologies, and enhancing data management systems to ensure sustainable industrial development while addressing the challenges posed by climate change.

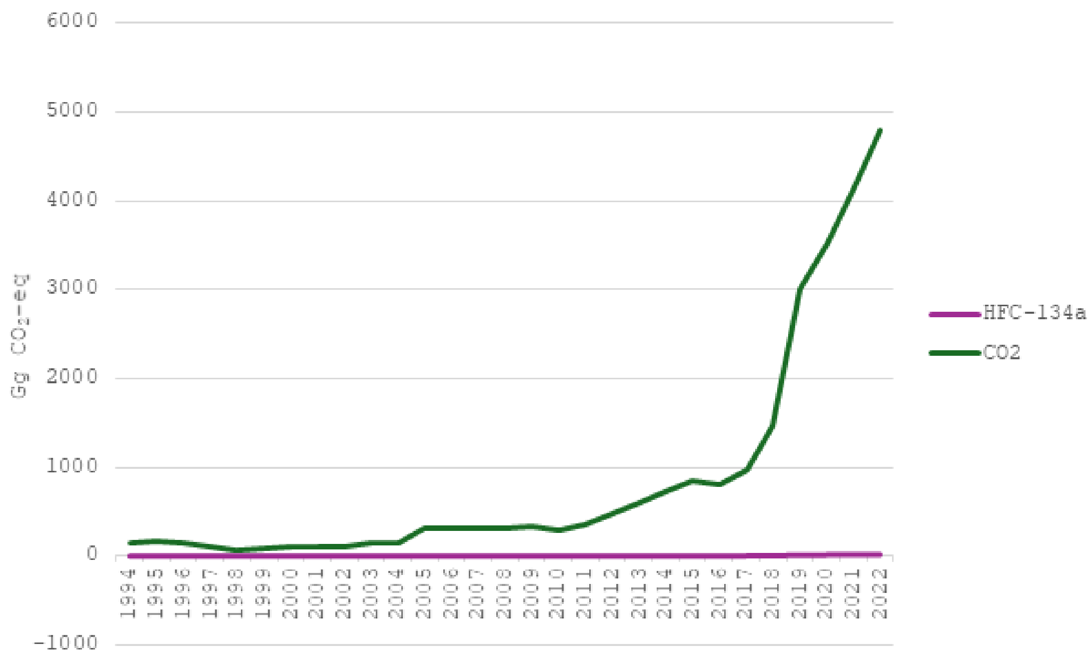


Figure 18: GHG emissions from IPPU sector from 1994-2022

3.5.5 Recalculation of emissions 1994-2011 with explanatory information and justifications

Figure 19 and Table 15 present the recalculated greenhouse gas (GHG) emissions from Nepal's Industrial Processes and Product Use (IPPU) sector for the years 1994 to 2011. These recalculations compare the emissions reported in the Initial National Communication (INC), Second National Communication (SNC), and Third National Communication (TNC) with updated estimates.

The INC reported emissions of 165 Gg CO_2-eq in 1995, but the revised value decreased to 162 Gg CO_2-eq. Similarly, the SNC reported 131 Gg CO_2-eq for 2001, while the recalculated value declined to 106 Gg CO_2-eq. For 2011, the TNC reported 380 Gg CO_2-eq, but the revised estimate shows a significant decrease to 350 Gg CO_2-eq.

The main reasons for these differences are updated methodologies. The recalculations use the improved emission factors provided in the IPCC 2006 guidelines, replacing those from the IPCC 1996 guidelines. Additionally, the INC and SNC relied on Global Warming Potential (GWP) factors from the Second Assessment Report (SAR), while the TNC used GWP factors from the Fourth Assessment Report (AR4). For these recalculations, GWP factors from the Fifth Assessment Report (AR5) were applied, along with updated activity data on production and product use. These updates provide a more accurate picture of emissions from the IPPU sector.

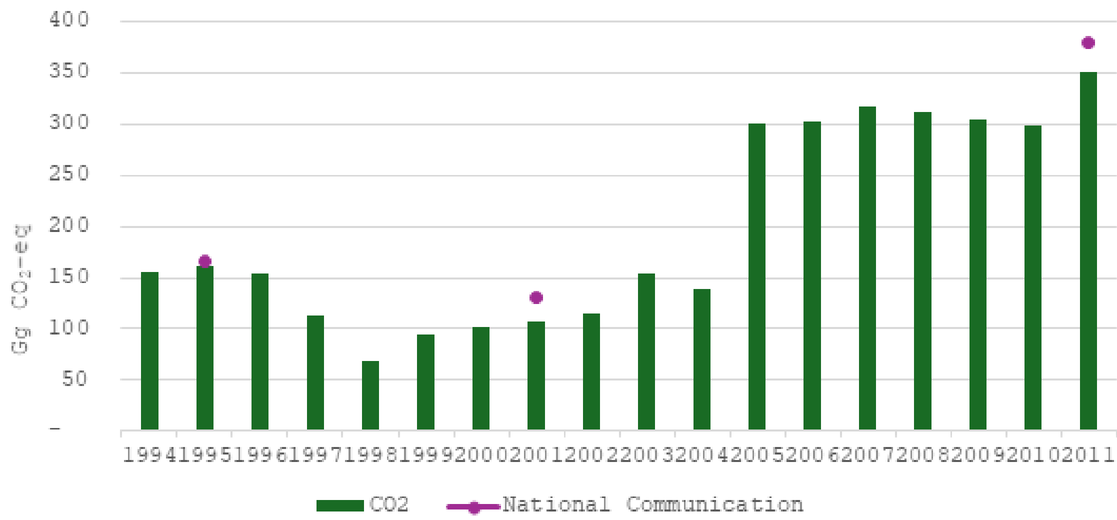


Figure 19: GHG emissions from IPPU sector during 1994-2011

Table 15: Recalculation of INC, SNC, and TNC GHG emissions

	INC (1995)	Revised INC	SNC (2001)	Revised SNC	TNC (2011)	Revised TNC
GgCO2-eq	165	162	131	106	380	350

3.5.6 Inventory development 2012-2022

Figure 19 provides calculation of the GHG inventory in the IPPU sector during 2012-2022. The GHG emissions in the IPPU sector are mainly carbon dioxide emissions from the cement industry during this period.

From 2012 to 2022, CO_2 emissions consistently dominated the emissions from the IPPU sector. The graph shows a steady increase in CO_2 emissions each year, reaching a sharp peak by 2022, where emissions equal nearly 4794.89 Gg CO_2-eq. This indicates an ongoing growth in industrial activities contributing to CO_2 emissions, particularly in the cement sector. The trend suggests that Nepal's industrial growth during this period has resulted in higher emissions, which reflects an increase in production capacities.

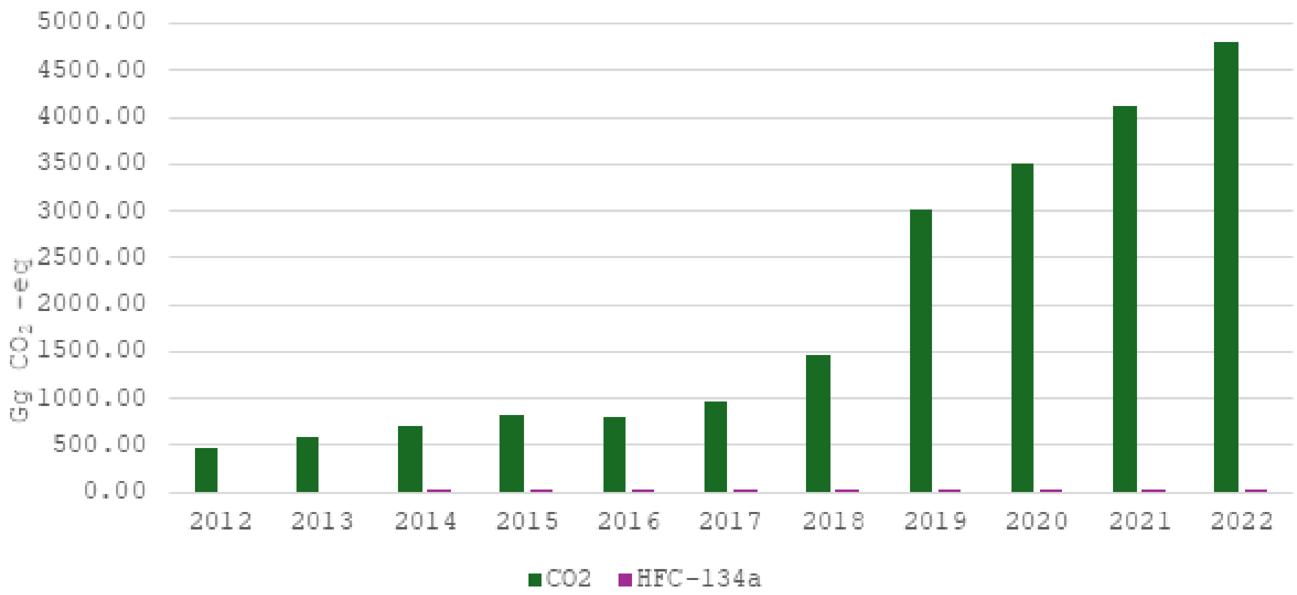


Figure 20: GHG emissions from IPPU sector during 2012-2022

3.5.7 Sectoral Emission in the year 2022

The data below shows the greenhouse gas emissions for 2022, focusing on CO_2 and HFC-134a from industrial activities. Most CO_2 emissions (4792.239 Gg) come from cement production, with smaller amounts from lubricants and paraffin wax. HFC-134a emissions (16.70 Gg) are entirely from refrigeration and air conditioning. This highlights cement production as a major CO_2 source and refrigeration as the main HFC-134a contributor.

Table 16: GHG emission from IPPU in the year 2022

Inventory Year: 2022	**CO_2**	**HFC-134a**
Category	Gg CO2-eq	Gg CO2-eq
2 - Industrial Processes and Product Use	4794.891	16.70256
2.A - Mineral Industry	4792.239	
2.A.1 - Cement production	4792.239	
2.D - Non-Energy Products from Fuels and Solvent Use	2.652027	
2.D.1 - Lubricant Use	1.899627	

2.D.2 - Paraffin Wax Use	0.7524	
2.F - Product Uses as Substitutes for Ozone Depleting Substances		16.70256
2.F.1 - Refrigeration and Air Conditioning		16.70256
2.F.1.a - Refrigeration and Stationary Air Conditioning		16.70256

3.5.8 Non-GHG emissions in the year 2022

The 2022 inventory of non-GHG emissions highlights key industrial sources and their contributions: Cement Production (2A1) is the largest contributor to SO_2 emissions at 2.91 Gg, while Food and Beverage Production (2H2) dominates NMVOC emissions at 1.48 Gg. Iron and Steel Production (2C1) contributes small amounts of SO_2 (0.0285 Gg), NO_2 (0.024 Gg), CO (0.0006 Gg), and NMVOC (0.019 Gg), and Pulp and Paper Production (2H1) adds minimally to NMVOC at 0.02 Gg. In total, SO_2 emissions reach 2.9385 Gg, NO_2 0.024 Gg, CO 0.0006 Gg, and NMVOC 1.519 Gg, with cement and food/beverage production being the most significant sources of SO_2 and NMVOC, respectively. This inventory underscores the varying impacts of industrial activities on air quality.

Table 17: Non-GHG emissions in the year 2022

Inventory Year: 2022				
Category	**SO_2 (Gg)**	**NO_2 (Gg)**	**CO (Gg)**	**NMVOC (Gg)**
2A1 Cement Production	2.91			
2C1 Iron and Steel Production	0.0285	0.024	0.0006	0.019
2H1 Pulp and Paper Production				0.02
2H2 Food and Beverage Production				1.48
Total	**2.9385**	**0.024**	**0.0006**	**1.519**

3.5.9 Uncertainty assessment and time series consistency

The analysis focuses on a base year (2012) and a target year (2022) to examine changes in uncertainties over time and their influence on emission trends. The data is organized based on the 2006 IPCC Guidelines. Cement production exhibits the highest activity data uncertainty at 78.89%, while refrigeration and stationary air conditioning use have the lowest at 5%. Regarding emission factor uncertainty, paraffin wax has the highest at 100.12%, and refrigeration and stationary air conditioning use the lowest at 0%. The combined uncertainty ranges between 5% and 102%. The dataset also analyzes how uncertainties in individual categories affect the overall variance in emissions for the target year and their influence on national emission trends.

Table 18: Uncertainty in IPPU

2006 IPCC Categories	Gas	Base Year Emissions ($GgCO_2$-eq)	End Year Emissions ($GgCO_2$-eq)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)
Cement production	CO_2	470.77	4792.239	78.89	4.5	79.02
Lubricant Use	CO_2	4.24	1.89	20	50.09	53.93
Paraffin Wax Use	CO_2	2.14	0.75	20	100.12	102.09
Refrigeration and Stationary Air Conditioning	HFC-134a	0	16.70	5	0	5

3.5.10 Category-specific QA/QC and verifications

In the process of estimating greenhouse gas (GHG) emissions for the development of Nepal's national inventory, Quality Control (QC) and Quality Assurance (QA) procedures play a critical role in ensuring the accuracy, reliability, and transparency of the data and methodologies used. These procedures are implemented throughout the inventory compilation process to minimize errors, verify results, and ensure that the inventory reflects the national context correctly.

Quality Control (QC) Process: The QC process in the Industrial Processes and Product Use (IPPU) sector is essential during the estimation of GHG emissions and removals. QC checks are conducted at multiple stages of the inventory development process to minimize potential errors and ensure the selection of appropriate data, emission factors, and parameters. Key QC activities include:

Data Selection: Ensuring the correct and relevant data is chosen for the estimation of emissions in each sector. This includes validating the activity data and emission factors based on local conditions and international guidelines.

Emission Factor and Parameter Selection: Carefully choosing emission factors and parameters from recognized sources, such as the IPCC Emission Factor Database (EFDB), EMEP-EEA (2016) guidelines and other relevant technical guidelines, to ensure consistency and accuracy in emissions calculations.

Unit Conversion: Verifying that all data and parameters are correctly converted to consistent units, following international standards, to ensure compatibility and comparability across different datasets.

Methodological Tiers: Ensuring that the correct methodological tiers (Tier 1, 2, or 3) are selected based on the availability of data and the level of detail required for the national context. This ensures that the methods used to estimate emissions are both scientifically sound and suitable for Nepal's data availability.

Computation Files: The QC process includes reviewing and verifying the Excel files and data inputs in the IPCC Inventory Software used for calculations. This ensures that the files are properly structured and that the formulas are correctly applied.

Evaluation of Trends: Checking trends in data and results to identify any inconsistencies or outliers that may indicate errors in the data or calculation processes.

Documentation: Keeping comprehensive records of all QC procedures, including the selection of data, emission factors, and methodology, as well as any assumptions made during the calculation process. This documentation helps provide transparency and accountability in the inventory process.

The QC Checklist follows the recommended QC procedures outlined in Table 6.1, Chapter 6, Volume 1 of the 2006 IPCC Guidelines, which includes 12 QC activities, each with specific procedures to check and verify the accuracy of the data and calculations.

Quality Assurance (QA) Process: The QA process provides an additional layer of validation to ensure the accuracy and reliability of the national GHG inventory. QA procedures focus on the validation of all data sources, assumptions, and methodologies used in the estimation of GHG emissions in the IPPU sector. The goal is to confirm that the results represent the national context accurately and are free from systematic errors. The key QA activities include:

Validation of Data Sources: Ensuring that all data used for estimating GHG emissions, including activity data and emission factors, are obtained from reliable and up-to-date sources. This involves reviewing national and international databases, official reports, and statistical records to confirm the accuracy and relevance of the data.

Methodology Validation: Verifying that the methods used to compile the GHG inventory are appropriate for the national context of Nepal. This includes ensuring that the methodologies selected align with international guidelines, such as the 2006 IPCC Guidelines and the EMEP-EEA (2016) guidelines.

Cross-Checking Results: Using the calculations methods of MS Excel and LEAP to cross-check the emissions results calculated in IPCC Inventory Software v2.95. The results from the IPCC Inventory Software should match those obtained from both the Excel and LEAP national inventory calculation files if the emissions calculations are correct.

Trend Evaluation: Analyzing the trends in emissions data to ensure that the calculated emissions reflect the expected national trends. This includes checking for any significant deviations or discrepancies in emissions data over time.

The IPCC Inventory Software v2.95, Excel and LEAP files are used in parallel for calculating and validating emissions. The Excel and LEAP files are developed specifically for Nepal's national context and incorporate local data and factors. The IPCC Inventory Software v2.95 is then used to ensure that the calculations and results are consistent with international standards.

The QA and QC processes are integral parts of the GHG inventory development in Nepal. They help ensure that emissions data are accurate, reliable, and reflect the national context. The combination of the IPCC Inventory Software v2.95, Excel, and LEAP-based calculations provides a comprehensive approach to emissions estimation, with multiple layers of validation and verification. These rigorous procedures ensure that the final national GHG inventory is transparent, scientifically sound, and aligned with international reporting standards.

3.5.11 Category-specific planned improvements

Table 19: Planned improvements for the IPPU sector in Nepal

Category	Planned Improvement
Data Collection System	Establish centralized data repositories for all activity data.
	Standardize data collection protocols and formats.
Capacity Building	Conduct regular training workshops on IPCC guidelines, GHG inventory software, and data analysis.
	Develop a national and international expert network for methodological support.
Addressing Data Gaps and Uncertainty	Implement annual or biennial data collection cycles.
	Minimize interpolation by improving direct data collection processes.
	Perform uncertainty analysis regularly to address variability in datasets.
Coordination and Stakeholder Engagement	Strengthen inter-ministerial coordination for seamless data sharing and policy alignment.
	Engage industries through incentives, training, and feedback mechanisms.
Policy and Institutional Framework	Introduce legal mandates for regular reporting of activity data by industries.
	Establish a dedicated unit for inventory preparation, verification, and improvement.
Monitoring, Verification, and Quality Control	Implement third-party audits for independent verification of data accuracy.
	Develop and apply QA/QC protocols to ensure compliance with IPCC standards.
Research and Development	Collaborate with academic institutions to develop emission factors and refine methodologies.
	Use forecasting tools for future emission projections and policy development.
Transparency and Reporting	Publish inventory results in accessible, user-friendly formats.
	Align reporting formats with UNFCCC and IPCC guidelines for consistency and compliance.

Climate Finance Integration	Leverage international climate finance to fund system upgrades.
	Integrate inventory data with carbon market mechanisms to support climate finance goals.

3.6 Agriculture, Forestry, and Other Land Use

The overall greenhouse gas emissions from AFOLU sector for the year 2022 are presented in the Table 20 below. The net emission from AFOLU sector is 3571.787488 Gg CO2-eq and most of the emissions occurred from Livestock and Agriculture sector.

Table 20: Emissions from AFOLU sector in 2022

Categories	**Net CO_2 emissions / removals**			
	CO_2	**CH_4**	**N_2O**	**Total**
	Gg	**Gg CO_2-eq**	**Gg CO_2-eq**	**Gg CO_2-eq**
3 - Agriculture, Forestry, and Other Land Use	**(19916.207)**	**20527.305**	**2960.689**	**3571.787**
3.A - Livestock		18199.968	523.532	18723.500
3.A.1 - Enteric Fermentation		16686.635	-	16686.635
3.A.2 - Manure Management		1513.333	523.532	2036.865
3.B - Land	(20021.958)			(20021.958)
3.B.1 - Forest land	(18072.100)			(18072.100)
3.B.1.a - Forest land Remaining Forest land	(18072.100)			(18072.100)
3.B.1.b - Land Converted to Forest land	-			-
3.B.1.b.i - Cropland converted to Forest Land	-			-
3.B.1.b.ii - Grassland converted to Forest Land	-			-
3.B.1.b.iii - Wetlands converted to Forest Land	-			-
3.B.1.b.iv - Settlements converted to Forest Land	-			-
3.B.1.b.v - Other Land converted to Forest Land	-			-
3.B.2 - Cropland	6345.516			6345.516
3.B.2.a - Cropland Remaining Cropland	6345.516			6345.516
3.B.2.b - Land Converted to Cropland	-			-
3.B.2.b.i - Forest Land converted to Cropland	-			-
3.B.2.b.ii - Grassland converted to Cropland	-			-
3.B.2.b.iii - Wetlands converted to Cropland	-			-
3.B.2.b.iv - Settlements converted to Cropland	-			-
3.B.2.b.v - Other Land converted to Cropland	-			-
3.B.3 - Grassland	(38.794)			(38.794)
3.B.3.a - Grassland Remaining Grassland	(38.794)			(38.794)
3.B.3.b - Land Converted to Grassland	-			-
3.B.3.b.i - Forest Land converted to Grassland	-			-
3.B.3.b.ii - Cropland converted to Grassland	-			-
3.B.3.b.iii - Wetlands converted to Grassland	-			-

3.B.3.b.iv - Settlements converted to Grassland	-			-
3.B.3.b.v - Other Land converted to Grassland	-			-
3.B.4 - Wetlands	-			-
3.B.4.a - Wetlands Remaining Wetlands	-			-
3.B.4.a.i - Peat Extraction remaining Peat Extraction	-			-
3.B.4.a.ii - Flooded Land remaining Flooded Land	-			-
3.B.4.b - Land Converted to Wetlands	-			-
3.B.4.b.i - Land converted for Peat Extraction	-			-
3.B.4.b.ii - Land converted to Flooded Land	-			-
3.B.5 - Settlements	(8256.580)			(8256.580)
3.B.5.a - Settlements Remaining Settlements	(8256.580)			(8256.580)
3.B.5.b - Land Converted to Settlements	-			-
3.B.5.b.i - Forest Land converted to Settlements	-			-
3.B.5.b.ii - Cropland converted to Settlements	-			-
3.B.5.b.iii - Grassland converted to Settlements	-			-
3.B.5.b.iv - Wetlands converted to Settlements	-			-
3.B.5.b.v - Other Land converted to Settlements	-			-
3.B.6 - Other Land	-			-
3.B.6.a - Other land Remaining Other land	-			-
3.B.6.b - Land Converted to Other land	-			-
3.B.6.b.i - Forest Land converted to Other Land	-			-
3.B.6.b.ii - Cropland converted to Other Land	-			-
3.B.6.b.iii - Grassland converted to Other Land	-			-
3.B.6.b.iv - Wetlands converted to Other Land	-			-
3.B.6.b.v - Settlements converted to Other Land	-			-
3.C - Aggregate sources and non-CO_2 emissions sources on land	105.750	2327.337	2437.157	4870.245
3.C.1 - Burning	-	-	-	-
3.C.1.a - Burning in Forest Land	-	-	-	-
3.C.1.b - Burning in Cropland	-	-	-	-
3.C.1.c - Burning in Grassland	-	-	-	-
3.C.1.d - Burning in all other land uses	-	-	-	-
3.C.2 - Liming	0.530			0.530
3.C.3 - Urea application	105.220			105.220

3.C.4 - Direct N_2O Emissions from managed soils			1673.180	1673.180
3.C.5 - Indirect N_2O Emissions from managed soils			682.551	682.551
3.C.6 - Indirect N_2O Emissions from manure management			81.424	81.424
3.C.7 - Rice cultivation		2327.337		2327.337
3.C.14 - Other (please specify)	-	-	-	-

3.7 Livestock

The livestock sector includes emissions of greenhouse gas (GSG) arise from various sources. The major sources are from (1) Enteric fermentation: animals like cattle, buffalo, goats, sheep, pigs, horse and mule emit methane and carbon dioxide during digestion, primarily through burping (2) Manure: Solid waste, dung, slurry of biogas plants generates, both methane and nitrous oxide. Among the several emitters, livestock are the major source of greenhouse gas in agriculture farming system. Methane is one of the major gases which has a 28 times higher effect on global warming than carbon dioxide. In general, the livestock agricultural feed system contributes about 12 percent of all anthropogenic greenhouse gas emissions.

3.7.1 Description of Livestock Sector in Nepal

Livestock contributes both directly and indirectly to climate change through the emissions of GHGs. The livestock sector includes methane (CH_4) from enteric fermentation and manure management, and direct N2O from manure management. Cattle are the most important livestock in Nepal which is integrated with crop agriculture for the livelihood of the small farmers. Methane emissions from manure management are reported to be usually smaller than those from enteric fermentation emissions. Considering the entire livestock commodity chain – from land use and feed production to livestock farming and waste management, to product processing and transportation – about 18% of total anthropogenic GHG emissions can be attributed to the livestock sector.

1. Enteric fermentation: Ruminants like cattle and sheep produce methane during digestion, primarily through burping. Ruminant animals, such as cattle, sheep, buffaloes, and goats, are unique due to their special digestive systems, which can convert plant materials that are indigestible by humans into nutritious food. In addition to food, these animals also produce hides and fibers that are utilized by humans. This same helpful digestive system, however, produces CH_4, a potent GHG that can contribute to global climate change

2 Manure Management: Solid waste generates both methane and nitrous oxide, with emissions varying based on management systems. Manure management systems differ in different agro-ecological zones on Nepal. Livestock rearing in general, and the rearing of large ruminants in particular, is dependent upon the overall farming system of the area. The farming systems at different altitudes are dependent upon temperature, irrigation and other interrelated factors, and will vary. For the large ruminants, three management systems predominate in Nepal, and they are:

A) Transhumance management system

This system is adopted in the high mountain areas where herds of cattle and buffalo migrate from one place to another throughout the year and utilizes forage resources available from the alpine pastures during the monsoon season, and crop stubble of fallow land during the winter season. During the upward and downward migration, the undergrowth in the forest region is the major forage source. The large ruminant animals involved in the system are the yak, chauri and mountain native cattle, but in some areas of lower mountain, buffalo are also included in transhumance system. As the herd is in migration, the dungs are (a) Collected and pills outside the shed (80% of the manure during night in camp) and (b) Scattered on the pastureland (20% of the outputs).

B) Sedentary system of management

Ruminant livestock makes daily grazing in nearby community land, forest, and return to shed every evening. The main grazing areas during the summer are the scrubland and community grazing land around the village. The sedentary population consists of working oxen, dry buffaloes and a small number of exotic cattle breeds such as Holstein Frisian. This system prevails at the lower altitudes of the midhills (900–1000m asl) and utilizes all the available forage in and around the village. The grazing area is usually degraded, and gully formation and soil erosion are evident. Though the animals spend half their time grazing, most of the forage resource is based upon crop-products and tree fodder during winter, and grasses and weeds from crop land during the summer, which are offered during evening and morning hours.

As the herd is in Sedentary system of management, the dungs are (a) Collected and pills outside the shed (80% of the manure during night in camp) and (b) Scattered on the community grazing land (20% of the outputs).

C) Stall-fed system of management

This type of animal rearing is found mainly in the low to mid-hills (400–900m asl) and peri-urban areas with milking buffalo, and exotic or crossbred cattle and buffalo. It is governed both by the availability of community grazing land in the village. The system prevails in areas of intensive cultivation (three crops per year), where the availability of crop by-products is adequate to maintain the animals in winter. In addition to crop by-products, tree fodder, grasses and weeds collected from the farmland also constitute an important forage source. As the animals are completely stalled fed and remain inside, the manure deposition is under the shed. Every day, manure is collected and kept in pits up to 1 meter above the ground level. The Figure 15 below shows the emissions by livestock sector in Nepal considered in this inventory.

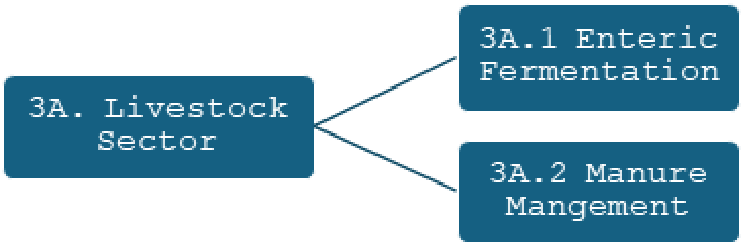


Figure 21: Categories included in Livestock Sector

3.7.2 Methodology

These emissions of greenhouse gas arise from various sources in livestock production, and these are as follows:

For this inventory, the emissions estimations from enteric fermentation and manure management system will be estimated using tier 1 method as per IPPC 2006 guideline.

For enteric fermentation the following equations will be used.

ANNUAL AVERAGE POPULATION

$$AAP = Day_{alive*}\ (NAPA/365)$$

Where:

AAP= annual average population

NAPA=number of animals produced annually

Source: (IPCC, 2006)

The above presented equation is used for estimating annual average population for growing population (eg. Meat animals, such broiler etc.). For static animal population (eg. Dairy cows, buffalo) annual average population is obtained simply as livestock population from livestock inventory data. The emission is then further estimated using the equation below:

Emission= EF(T)*(N(T)/106)

Where:

Emission: methane emission from enteric fermentation, Gg CH_4 yr-1

EF(T): emission factor for the defined livestock population, kg CH_4 head-1 yr-1

N(T): number of head of livestock species/ category T in the country

T: species/category of livestock

Then,

Total CH_4 Enteric = ΣEi

Where:

Total CH_4 Enteric: total methane emission from enteric fermentation, Gg CH_4 yr-,

Ei=is the emission for the ith livestock categories and subcategories

Source: IPCC, 2006

For CH_4 from manure management the following equation will be used.

$$CH_{4\,Manure} = \sum \frac{(EF_{(T)} * N_{(T)}}{10^6}$$

Where:

CH_4 Manure = CH_4 emissions from manure management, for a defined population. Gg CH_4 yr-1

EF(T) = emission factor for the defined livestock population, kg CH_4 head-1 yr-1

N(T) = the number of head of livestock species/category T in the country

T = species/category of livestock

Source: IPCC, 2006

The equation presented below will be used for estimating direct N2O from manure management.

DIRECT N_2O EMISSIONS FROM MANURE MANAGEMENT

$$N_2O_{D(mm)} = \left[\sum_S \left[\sum_{(T)} (N_{(T)} * Nex_{(T)} * MS_{(T,S)} \right] * EF_{3(S)} \right] * \frac{44}{28}$$

Where:

N2OD(mm) = direct N_2O emissions from manure management in the country, Kg N_2O yr-1

N (T) = number of head of livestock species/category T in the country

Nex(T) = annual average N excretion for each livestock species/category T that is managed in manure management system S in the country, dimensionless

EF(T,S) = emission factor for direct N_2O emissions from manure management system S in the country, kg N_2O-N/kg N in manure management system S

S = manure management system

T= Species/category of livestock

44/28 = conversion of (N_2O-N)(mm) emissions to N_2O(mm) emissions

Source: IPCC, 2006

The Table 21 below presents the category and the method used for the inventory

Table 21: Livestock sector category and method that will be used for GHG Inventory

Category	Gases	Method	Required Data	Data Source
3A.1 Enteric Fermentation	CH_4	T1	Livestock population head	• Ministry of Agriculture and Livestock Development • Department of Livestock Services, • Third National Communication • FAO Stat • National Statistics Office
3A.2 Manure Management	CH_4	T1	Livestock population head	• Ministry of Agriculture and Livestock Development • Department of Livestock Services, • Third National Communication • FAO Stat • National Statistics Office
	Direct N_2O	T1	Livestock population head	• Ministry of Agriculture and Livestock Development • Department of Livestock Services, • Third National Communication • FAO Stat • National Statistics Office

3.7.3 Activity data

The data collection for the livestock sector involves direct data requests from the Ministry of Agriculture and Livestock Development (MOALD), KII and collection of published data. The time series data on livestock population (MOALD, 2023) published by MOALD is used for livestock population. Similarly, the year-wise livestock population published by MOALD every year were also collected for livestock population, supplemented by national statistics, surveys and FAOSTAT. The activity data for emission inventory of livestock sector from 2012-2022 is presented in Annex VII.I

3.7.4 Emission factors

The default emission factors provided by IPCC guidelines for Indian subcontinent are used for emission estimation of CH_4 and N_2O as presented in Annex VII.III

3.7.5 Trend of Emission in Livestock Sector

The Figure 22 shows the trend of GHG emission from 1994-2022. The trend shows the increasing trend of GHG emissions. The CH_4 emission from both enteric fermentation and manure management also shows the increasing trend. Similarly, the N_2O emission also shows an increasing trend from 1994-2022. The data associated with emission trend for livestock sector is presented in Annex VII.VIII

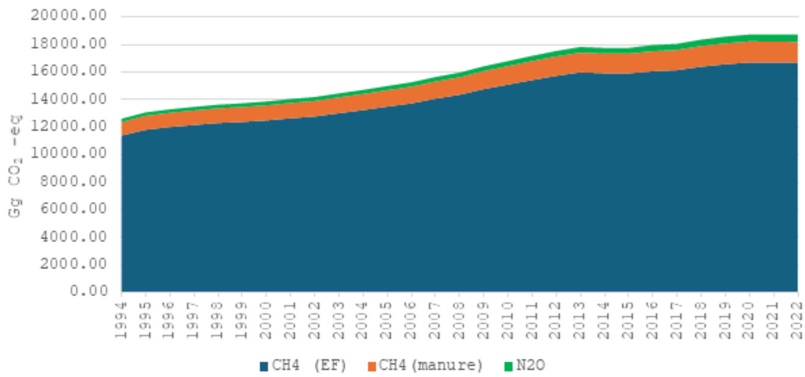


Figure 22: Emission trend in livestock sector

3.7.6 Recalculation of emissions 1994-2011

The Figure23 presents the recalculation of GHG for livestock sector for years 1994 to 2011(Annex VII.V) based on IPCC 2006 guidelines. The emission reported in Initial National Communication (INC), Second National Communication (SNC), and Third National Communication (TNC) are compared with the recalculated value. The dark black outlined bar indicates the GHG values in Gg CO_2-eq as reported in the National Communication Report that are different from the recalculated emission due to the use of the improved emission factors provided in the IPCC 2006 guidelines in recalculation. Furthermore, while the INC and SNC use the global warming potential (GWP) factor from the Second Assessment Report (SAR) while the TNC uses the GWP factors from the Fourth Assessment Report (AR4) however GWP factors from the Fifth Assessment Report (AR5) were applied for recalculation.

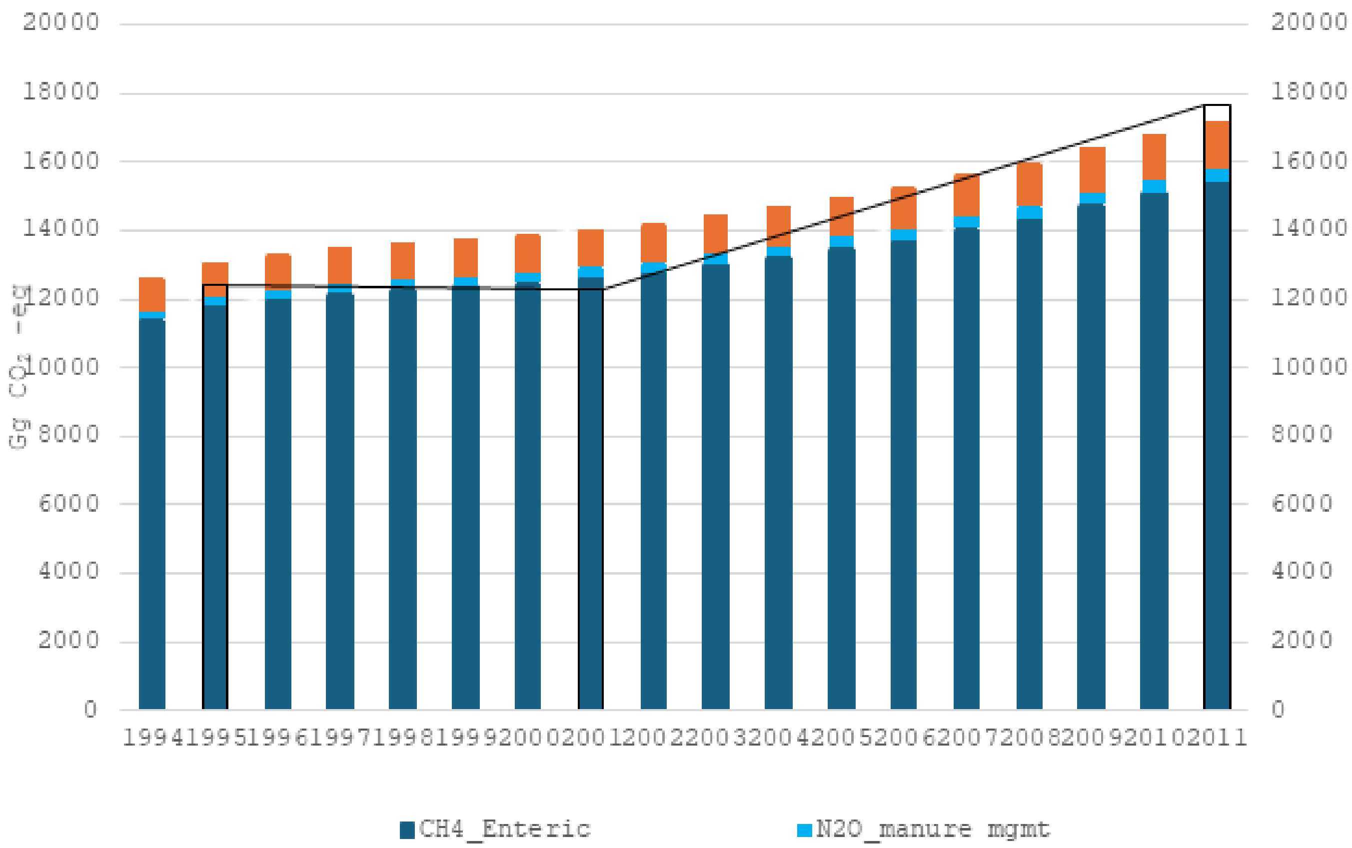


Figure 23: Recalculation of Livestock Sector for Year 1994-2011

3.7.7 Inventory development 2012-2022

The GHG inventory of the year 2012-2022 for livestock sector is presented in the Figure 24. The GHG inventory has been carried out using IPCC software. The graph shows a slightly increasing and decreasing and then again increasing trend reaching a sharp peak by 2022, where emissions exceed 18,700 Gg CO_2-eq which is due to change in the population of livestock each year. The trend shows that emissions due to both enteric and manure management are increasing gradually and the emissions due to manure management are comparatively lower than enteric fermentation.

Furthermore, the graph shows that direct N_2O has a lower contribution to total emission than methane. The manure management system such as dry lot, solid storage, anaerobic digestor and pasture/paddock were considered for this inventory development.

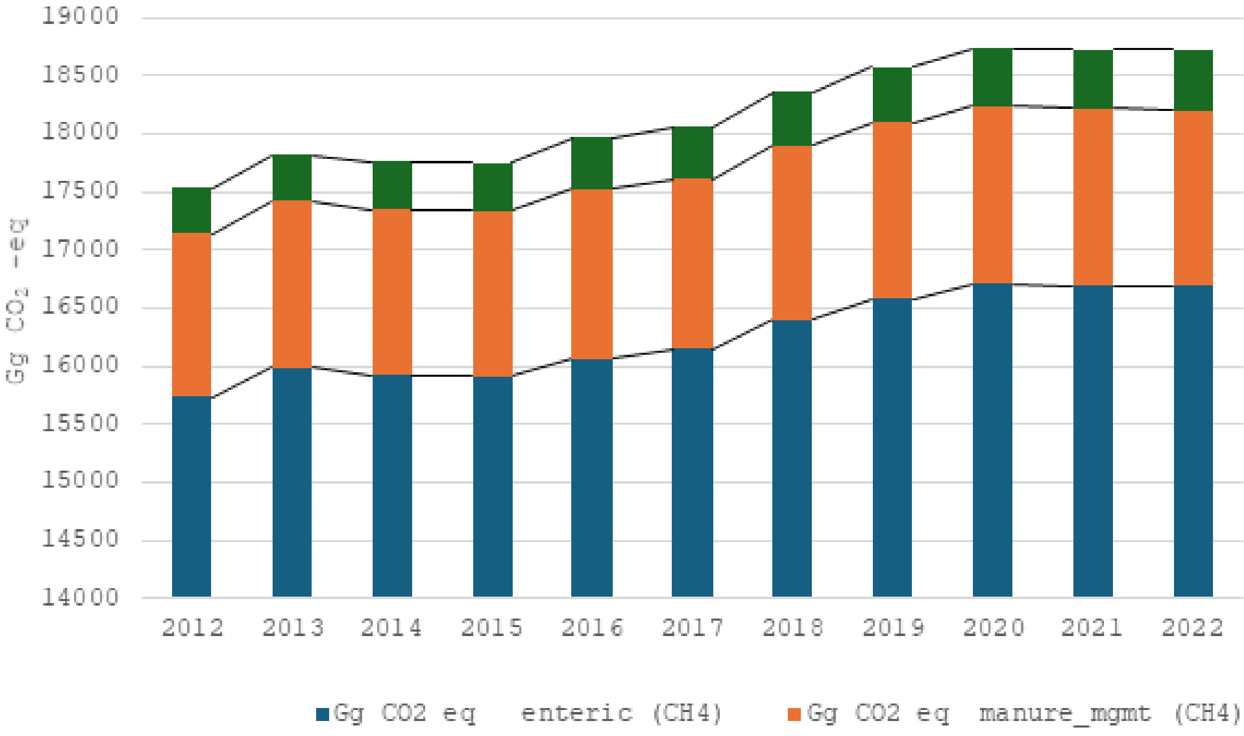


Figure 24: GHG Inventory of Livestock Sector for Year 2012-2022

3.7.7.1 Category-wise emission for year 2022

In the livestock sector, CH_4 emission from enteric fermentation has a greater share i.e. 91.4% of total sectoral emission as presented in the Figure 19, followed by 8.3% CH_4 emission from manure management and 0.3% N_2O emission from manure management.

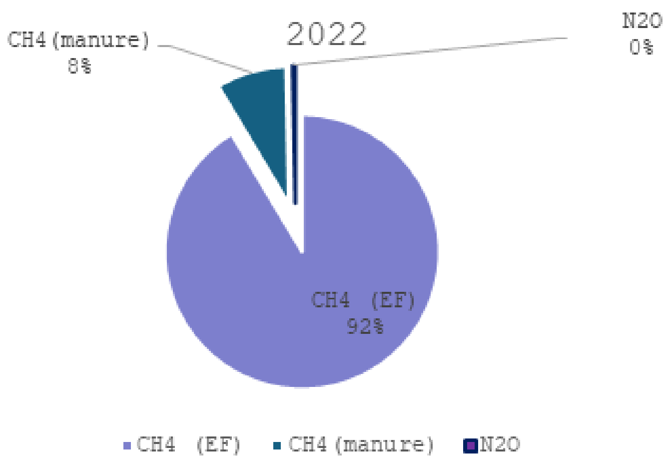


Figure 25: Total emission for the livestock sector for the year 2022

Table 22: GHG emissions from the livestock sector in 2022

Categories	**Net CO_2 emissions/removals**		
	CH_4	**N_2O**	**Total**
	Gg CO_2 -eq	**Gg CO_2 -eq**	**Gg CO_2 -eq**
3.A - Livestock	**18199.968**	**523.532**	**18723.500**
3.A.1 - Enteric Fermentation	16686.635		16686.635
3.A.1.a - Cattle	6665.993		
3.A.1.a.i - Dairy Cows	1986.251		
3.A.1.a.ii - Other Cattle	4679.742		
3.A.1.b - Buffalo	7904.713		
3.A.1.c - Sheep	107.968		
3.A.1.d - Goats	1958.698		
3.A.1.e - Camels	-		
3.A.1.f - Horses	5.541		
3.A.1.g - Mules and Asses	1.590		
3.A.1.h - Swine	42.129		
3.A.1.i - Poultry	-		
3.A.1.j - Other (please specify)	-		
3.A.2 - Manure Management	1513.333	523.532	2036.865
3.A.2.a - Cattle	517.876	31.592	
3.A.2.a.i - Dairy cows	171.229	1.682	
3.A.2.a.ii - Other cattle	346.648	29.911	
3.A.2.b - Buffalo	718.610	58.920	
3.A.2.c - Sheep	3.239	9.600	
3.A.2.d - Goats	66.594	393.303	
3.A.2.e - Camels	-	-	
3.A.2.f - Horses	0.505	0.823	
3.A.2.g - Mules and Asses	0.143	0.232	
3.A.2.h - Swine	168.518	12.167	
3.A.2.i - Poultry	37.749	15.191	
3.A.2.j - Other (please specify)	0.097	1.703	

3.7.8 Uncertainty assessment and time series consistency

The uncertainty analysis is done using IPCC software for base year (2012) and end year (2022). Since the nation lacks both disaggregated activity data and national EF (validated by government) as required by the 2006 IPCC guideline, the default emission factor is considered for this inventory resulting higher uncertainty associated. The uncertainty associated with the activity data for livestock sector is assumed to be ±20% (as per IPCC guideline). The uncertainty associated with the default excretion rate is assumed to be ± 50 (as per IPCC guideline). The uncertainty of default emission factors as per IPCC 2006 guideline are presented in the table below:

Table 23: Uncertainty in livestock sector

Category	Activity Data	Uncertainty associated with default emission factor/value	Combined Uncertainty for default emission factor/value
Enteric Fermentation (CH_4)	±20	±30- 50%	

Manure Management (CH4)	±20	±30	
N Excretion Rate (Default value)	-	±50	-70.71 to + 111.8
Manure Management System (N2O)	±20	-50% (lower value) to +100% (higher value)	

The uncertainties associated with each category are presented in Annex IV.

The combined uncertainty was calculated by applying the formula:

$$U=\sqrt{((U1)^2+(U2)^2)}$$

3.7.9 Data Quality Assurance, QA, and Quality Control

The inventory is carried out considering the UNFCCC reporting principles, ensuring transparency, accuracy, clarity, completeness, and consistency (TACCC). Moreover, the following processes are used to ensure QA/QC:

- Utilization of government-owned or government-published data and verified web-based sources only
- proper documentation of datasets
- Data from one source is cross-checked with other sources
- source references for all data sources

3.7.10 Category-specific planned improvements

Category	Challenges/Limitations	Necessity
Updated Data and Data Availability	- Lack of proper historical data for recalculation and trend analysis. - Limited centralized database for systematic updates.	- Accurate and updated data is essential for precise GHG estimation and tracking emission trends
Disaggregation Data Suitable for IPCC Guidelines	- Disaggregated data does not align with IPCC guidelines (e.g. fraction of manure management system, N excretion rate)	- Disaggregated data enables compliance with IPCC standards and improves sector-specific emission calculations.
Research to Establish National Emission Factors	- National emission is available for some livestock, however, not validated by the government - Validation and authenticity of available scientific data	- National emission factors improve accuracy as they reflect local conditions. - The available scientific data is to be validated by in-line agencies for their use and authenticity

3.8 Agriculture

The agriculture sector (here, excluding the enteric fermentation and direct emissions from manure management) is one of the major GHG emissions. According to the World Resources Institute Climate Analysis Indicators Tool (WRI CAIT), half (50.1%) of Nepal's 2014 GHG emissions were from the agriculture sector. Within the agriculture sector, 46% of emissions were from crop agriculture. In 2021, the agriculture sector produced 55.1% of Nepal's total GHG emissions (GCP, 2023), meaning that emissions from this sector represent a significant share of national emissions. This inventory analysis reveals that the key emission sources in this sector include methane emission from rice cultivation (3C7 as per IPCC 2006 guideline), direct (3C4) and indirect (3C5) N_2O emissions from synthetic fertilizers, animal manure and urine and dung deposited to soils (croplands/PRP), CO_2 emission from urea application (3C3), indirect N2O emission from manure management (3C6) and CO_2 emission from liming ($3C_2$), order placed based on their contribution.

3.8.1 Methodology

This inventory follows the methodologies as per IPCC 2006 guidelines. For the inventory of this section, Volume 4, Chapter 5: Cropland and Chapter 11: N_2O emission from Managed Soils and CO_2 emission from Lime and Urea Application were referred for calculation of CH_4 emission from rice cultivation; CO_2 emissions from urea and lime application; and direct and indirect N_2O emission from managed soils, synthetic fertilizer, organic manure and urine and dung depositions to grazed lands and from manure management. Since data on crop residue burning, which contributes to CO_2 emissions, and on cover crops and legumes that enrich soils with nitrogen is unavailable, as well as the lack of data on nitrogen addition through soil mineralization, these factors have not been included in the emission calculations. Figure 26 shows the categories and sub-categories included for the inventory while Table 24 presents the summary of categories and sub-categories included, type of gases emitted, methodology used and data sources for the calculation of GHG emissions. The equations used for the calculation of the GHG emission rates are stated in the later sections.

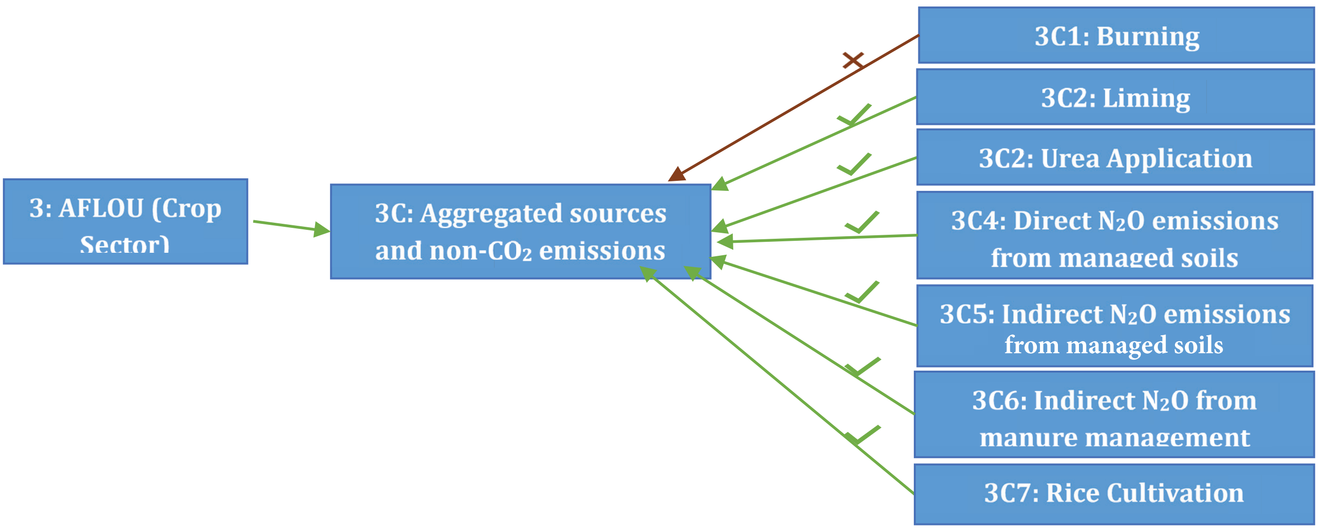


Figure 26: Categories included in the crop sector for Nepal's GHG Inventory

Table 24: Categories for GHG emission selected for GHG Inventory of Agriculture Sector along with Type of GHGs, Methods Applied and Data Sources

Category	GHGs	Method	Required Data	Data sources
Rice cultivation	CH_4	T1	Harvest area that is continuously flooded, single aerated, multiple aerated, regularly rainfed, and rainfed drought-prone; data on organic amendment rate of application, crop growth duration	Statistical Information on Nepalese Agriculture yearly book by the MoALD (the then MoAC). Irrigation and rainfed rice fields based on experts' judgment. Maintained consistency over time.
Urea application	N_2O	T1	The rate of urea applied in the rice field	Statistical Information on Nepalese Agriculture yearly book by the MoALD (the then MoAC).

Liming	CO_2	T1	Lime application rate and amount	Agriculture Input Company Ltd. Private sector contribution is based on expert judgment
Direct N_2O emission from managed soil	N_2O	T1	Use of synthetic fertilizer emitting N2O, organic manure applied to rice fields and other cropland or soils, urine and dung deposition in pasture, range, and paddock.	Livestock population head data from the Statistical Information on Nepalese Agriculture yearly book by the MoALD (the then MoAC). Other data is based on expert judgement.
Indirect N_2O emission from managed soil	N_2O	T1	Synthetic fertilizers emitting N are applied to rice fields and other soils, organic manure is applied to rice fields and other managed soils, and urine and dung are deposited on grazed lands.	DAP and Urea data from Statistical Information on Nepalese Agriculture, a yearly book by the MoALD (the then MoAC). Other data are based on Livestock population head and experts' judgment.
Indirect N_2O emission from manure management	N_2O	T1	Total livestock population and N excreted	Yearbook Statistical Information on Nepalese Agriculture (MoALD)

3.8.1.2 All the activity data used for the calculation of the emission from all the above-mentioned sources is in Annex VIII.I. The livestock population data is the same as that used in Section 9.6.

3.8.1.3 Urea Application

The CO_2 emissions from the area application were calculated using Equation 11.3 from the IPCC 2006 guidelines (Equation 9.7.1). The detailed calculations are provided in Annex VIII.II. An emission factor of 0.2, as specified by the IPCC guidelines, was used for this analysis. It is assumed that the urea sales data corresponds to its application on croplands. Approximately 70% of the urea is estimated to be used in rice fields, as rice is the country's primary crop, with the remaining applied to other crops.

$$CO_{2_{Urea}} = M_{urea} * EF_{Urea} * \frac{44}{12}$$

where,

CO_2 Emission = annual CO_2 emissions from urea application, tonnes per year

M = annual amount of urea fertilization, tonnes of urea per year

EF = emission factor, tonne of C per tonne of urea

3.8.1.4 Lime Application

The carbon dioxide emissions from lime application in agricultural soils were calculated based on sales data provided by AICL. It is assumed that the private sectors contribute an additional 20% of lime sales, which are not officially recorded. However, AICL provided data for only four years, from 2019 to 2022. For earlier years, no data was available, so the inventory assumes a consistent application of 320.79 tonnes of lime annually from 1994 to 2019.

The CO_2 emissions were calculated using Equation 9.7.2 from the IPCC 2006 Guidelines (Volume 4, Chapter 11, Equation 11.13). The inventory excludes dolomite due to a lack of data and assumes that 100% of the lime is limestone. Using an emission factor of 0.12 tonnes of carbon per tonne of limestone, the total annual emissions were calculated.

$$CO_{2_{liming}} = M_{limestone} * EF_{limestone} * \frac{44}{12}$$

where,

CO_2 liming = annual C emissions from lime application, tonnes C yr-1

M = annual amount of calcic limestone ($CaCO_3$) applied in tonnes per year

EF = emission factor, tonne of C per tonne of limestone

3.8.1.5 Rice cultivation:

Equations 5.1 and 5.2 of the IPCC 2006 guideline were used to estimate methane emissions from rice cultivation and adjusted daily emission factors. Equation 9.7.3 and 9.7.4 show the equation used for methane emission calculation and for calculating the adjusted daily emission factor for rice cultivation.

$$CH_{4_{Rice}} = \left(EF_{ijk} * t_{ijk} * A_{ijk} * 10^{-6}\right)_{ijk}$$

Where:

CH_4 Rice = annual methane emissions from rice cultivation, Gg CH_4 yr-1

EFijk = a daily emission factor for i, j, and k conditions, kg CH_4 ha-1 day-1

tijk = cultivation period of rice for i, j, and k conditions, day

Aijk = annual harvested area of rice for i, j, and k conditions, ha yr-1

i, j, k = represent different ecosystems, water regimes, type and amount of organic amendments, and other conditions under which CH_4 emissions from rice may vary

For adjusted daily emission factor, the formula is in Equation 9.7.4, as follows

$$EF_i = EF_c * SF_w * SF_p * SF_o * SF_{sr}$$

Where:

EFi = adjusted daily emission factor for a particular harvested area

EFc = baseline emission factor for continuously flooded fields without organic amendments

SFw = scaling factor to account for the differences in water regime during the cultivation period (from Table 5.12)

SFp = scaling factor to account for the differences in water regime in the pre-season before the cultivation period (from Table 5.13)

SFo = scaling factor should vary for both type and amount of organic amendment applied (from Equation 5.3 and Table 5.14)

SFs,r = scaling factor for soil type, rice cultivar, etc., if available

Source: IPCC 2006

The emission factors and assumption used for calculation are in Table 25 and Table 26.

Table 25: Emission factors, scaling factors and conversion factors used for CH_4 emission calculation

SN	Category	Emission Factor (EF)		Scaling Factor (SF)		Conversion Factor (CF)	
		1996	2006	1996	2006	1996	2004
1	Baseline emission factor	10 (as of India)	1.3				
2	Continuously flooded harvest area			1	1		
3	Single aerated irrigated area			0.5	0.6		
4	Multiple aerated irrigated area			0.2	0.52		
5	Regularly rainfed area			NA	0.28		
6	Drought prone rainfed area			0.4	0.25		
7	Non flooded pre-season for more than 180 days				0.68		
8	Organic amendment for FYM application				1.15679 (for 2ton/ha of FYM)	2	0.14

Table 26: Assumption in calculating methane emission from rice cultivation

SN	Conditions
1	8% upland area
2	1994/95-1995/1996 = 50% irrigated area; 1996/1997-2009/10 = 60% irrigated area; 2010/11-2021/22 = 65% irrigated area
3	10% of irrigated areas are continuously flooded; 90% intermittently flooded
4	10% of irrigated area are single aerated
5	80% of the area are multiple aerated
6	No flood prone rainfed area harvested
7	No deep-water type of rice cultivated area
8	Out of total rainfed area, 50% are regular rainfed while other half is drought prone
9	Scaling factor for non-flooded pre-season of >180 days considered as mostly rice crops is followed by wheat/maize
10	FYM is applied to rice fields at 2 ton/ha
11	Growing period = 120 days
12	scaling factor for soil type, rice cultivar not available
13	Irrigated growing period 130; rainfed growing period 120 days

3.8.1.6 Direct N_2O Emission from Managed Soils

The inventory follows the formulas and equations outlined in Chapter 11 of the IPCC 2006 Guidelines. The inventory used formula modified from that of equation 11.1 as per the availability of data as stated in Equation 9.7.5

$$N_2O_{Direct}N = N_2O - N_{inputs} + N_2O - N_{PRP}$$

The N_2O N that are added to the soils is calculated from the formulation in Equation 9.7.6.

$$N_2O - N_{inputs} = [\{(F_{SN} + F_{ON}) * EF_1\} + \{(F_{SN} + F_{ON}) * EF_{1FR}\}]$$

And, N_2O N that are added to the pasture, range and paddock is calculated by using Equation 9.7.7

$$N_2O - N_{PRP} = [(F_{PRP\ CPP} * EF_{2PRP\ CPP}) + (F_{PRP\ SO} * EF_{2PRP\ SO})]$$

Where,

N_2ODirect –N = annual direct N_2O–N emissions from managed soils, kg N_2O–N per year

N_2O–Ninputs = annual direct N_2O–N emissions from N inputs to managed soils, kg N_2O–N yr-1

N_2O–NPRP = annual direct N_2O–N emissions from urine and dung inputs to grazed soils, kg N_2O–N yr-1

FSN = annual amount of synthetic fertilizer N applied to soils, kg N yr-1

FON = annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils

FPRP = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr-1 (Note: the subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively)

EF1 = emission factor for N_2O emissions from N inputs, kg N_2O–N (kg N input)-1(Table 11.1)

EF1FR is the emission factor for N_2O emissions from N inputs to flooded rice, kg N_2O–N (kg N input)-1

EF_2PRP = emission factor for N_2O emissions from urine and dung N deposited on pasture, range, and paddock by grazing animals, kg N_2O–N (kg N input)-1

For the calculations, it is assumed that about 70% of the total urea and DAP sales are applied to rice fields, while the remaining 30% is used for other crops, including cereals and vegetables. Additionally, it is assumed that of the total nitrogen (N) available in organic manure for various uses, managed soils, fuel, and construction, 50% is used as fuel, 20% is applied to rice fields, and the rest is used on managed soils other than rice fields.

The total nitrogen available for these purposes is calculated by applying factors that account for losses from different manure management systems.

Although this inventory aims to include as many relevant factors as possible, some data gaps remain. Due to the lack of information on the annual amount of nitrogen mineralized in soils, soil carbon loss from organic matter due to land use or management changes, the annual area of managed or drained organic soils, and crop residues incorporated or burned, nitrogen additions and emissions from these factors are not included in the inventory.

3.8.1.7 Indirect N_2O emissions from Managed Soils

For indirect N_2O emissions from managed soils, two sources are considered: N_2O emissions from atmospheric deposition of nitrogen (N) volatilized from soils and N_2O emissions from nitrogen leaching and runoff.

It is assumed that 10% of the nitrogen applied through synthetic fertilizers and 20% of the nitrogen from organic manure, as well as urine and dung applied to pasture, range, and paddock (PRP), are volatilized. These volatilized fractions are then multiplied by an emission factor of 0.01 kg N_2O-N per kg of volatilized nitrogen to estimate N_2O emissions from atmospheric deposition.

For emissions from leaching and runoff, the total nitrogen applied to managed soils through synthetic fertilizers, organic manure, and urine and dung is multiplied by the fraction susceptible to leaching and runoff and by the emission factor of 0.0075 kg N_2O-N per kg of nitrogen lost through leaching or runoff.

3.8.1.8 Indirect N_2O emission from Manure Management

The indirect N_2O emissions from the manure management are calculated for manure N lost due to volatilization of NH_3 and Nox. The total N excretions from different livestock species are multiplied by their respective fractions for volatilization and by the emission factor for N_2O emission. N loss due to leaching has not been included in the inventory.

3.8.2 GHG emissions from the Sector

3.8.2.1 Trend of GHG emission in the agriculture sector from 1994-2022

Emissions from the sector generally increased from 1994 to 2022, at a rate of 1.23% per year. Methane emissions from rice cultivation consistently contribute the largest share, followed by direct nitrous oxide (N_2O) emissions from managed soils. Indirect N_2O emissions from both managed soils and manure management show a gradual increase over the years, while carbon dioxide (CO_2) emissions from liming and urea application remain minimal. A more pronounced rise in emissions is observed from 2010 onward, indicating a growing impact of agricultural activities on greenhouse gas emissions. This trend highlights the need for climate-smart agricultural practices to mitigate emissions, particularly from rice cultivation and soil management. The graph (Figure 27) illustrates the trend in GHG emissions from agricultural activities over time, measured in gigagrams (Gg) of CO_2 equivalent.

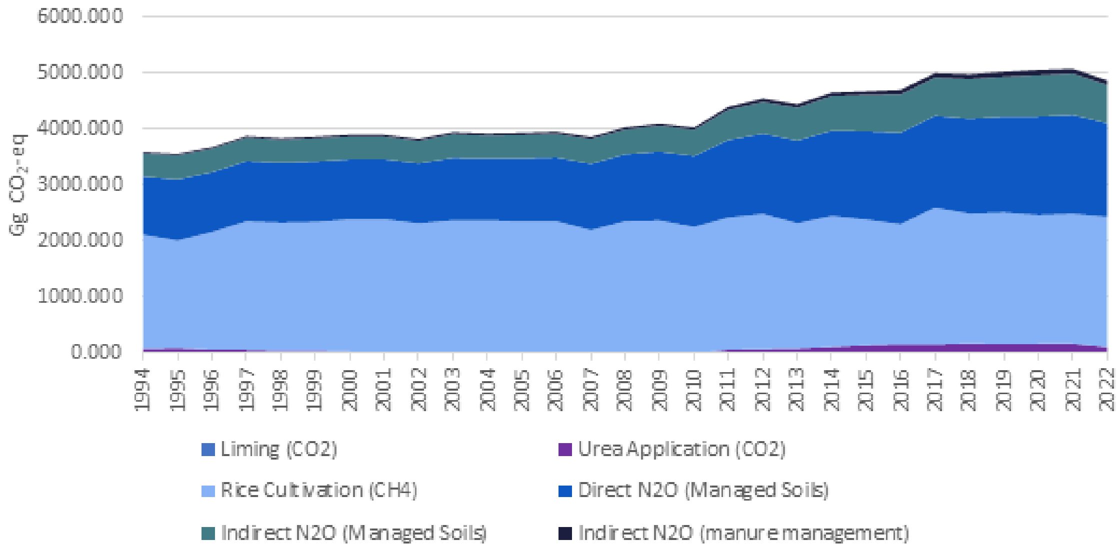


Figure 27: GHG emission trend in agriculture sector from year 1994-2022

In the year 2022, the total GHG emissions from the sector was 4870.25 Gg of CO_2 equivalent. Of the total emission within the sector, the highest contribution was from rice cultivation (47.7%) followed by direct N_2O emission from managed soils (34.36%), while about 18 % were contributed form other sources. Figure 28 shows the chart showing contribution of different sources for the year 2022.

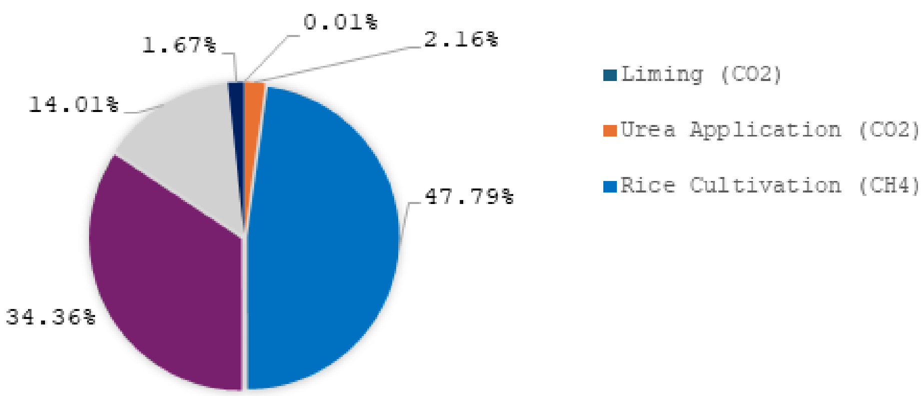


Figure 28: Contribution of different sources for year 2022

3.8.2.2 Recalculation of GHG emissions from 1994 to 2011 for crop sector.

The total emissions from the sector including all the emission sources were 3587.10 Gg CO_2-eq

for the year 1994 while for the year 2011 the emission rose to 4345.51 Gg CO_2-eq. Over the period of 18 years emissions increased by 21.14% (with a p.a. increase rate at 1.175%). Within the sector, rice cultivation has significantly contributed to the emission over years. Figure 29 presents the emissions within the sector categorized under different sources. The emission calculated for different source categories is in Annex VIII.V.

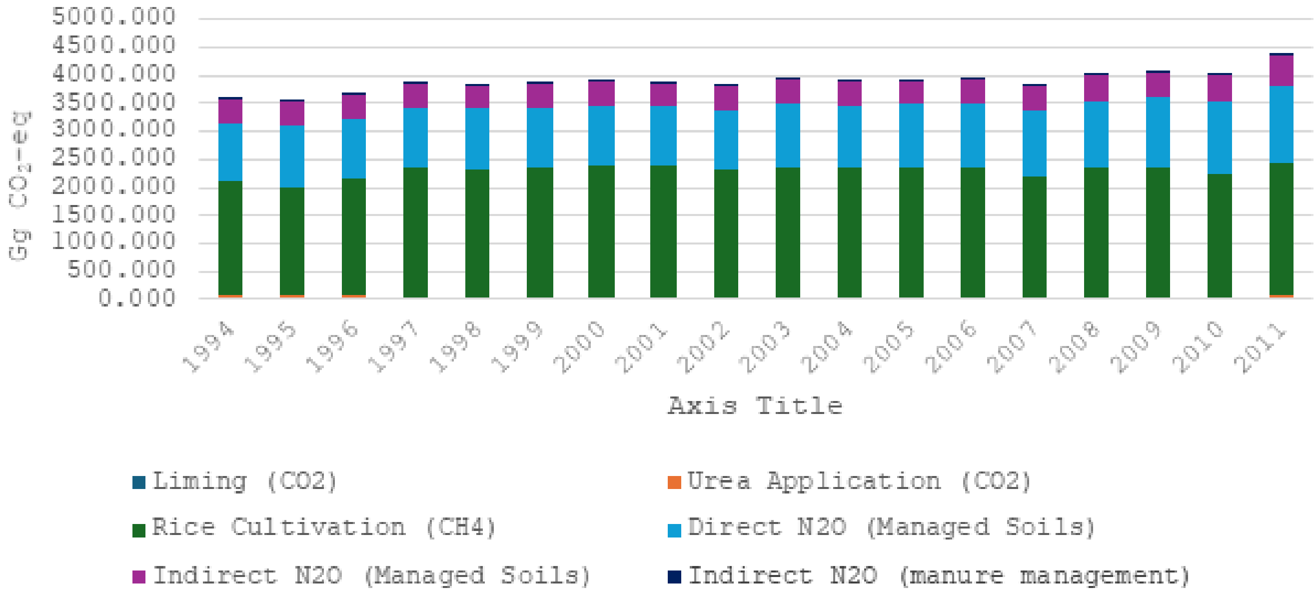


Figure 29: GHG emissions from the agriculture sector from year 1994-2011

Urea Application (3C3)

Figure 30 shows CO_2 emissions from urea application over 18 years. A decline in urea applications occurred due to the reduction of government subsidies until 2009. However, with the development and endorsement of an operational modality for subsidy administration by MoAD and MoF, the subsidies were reintroduced, thereby leading to an increase in urea sales and application after 2010.

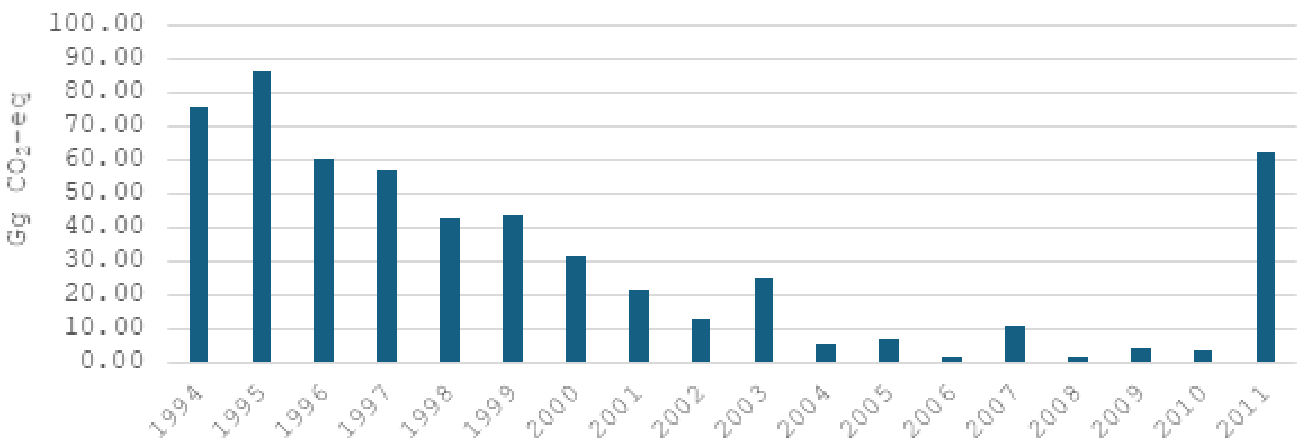


Figure 30: CO2 emissions from year 1994 to 2011 by urea application

Lime application

Due to the lack of sufficient data on lime application, expert judgment was used to assume that the amount of lime applied remained constant at 320.79 tonnes per year from 1994 to 2019. Based on this assumption, the annual CO_2 emissions from lime application were calculated to be 141.15 tonnes per year.

Rice cultivation (3C7)

The activity data, which include time-series information on urea applied (in tonnes per year) from 1994 to 2011, are provided Annex VIII.I and the year-wise calculated CH_4 emissions are included in Annex VIII.V. Figure 31 illustrates methane emissions from rice cultivation over 18 years. The harvested area for rice has remained relatively constant over the years, resulting in a nearly stable emission trend.

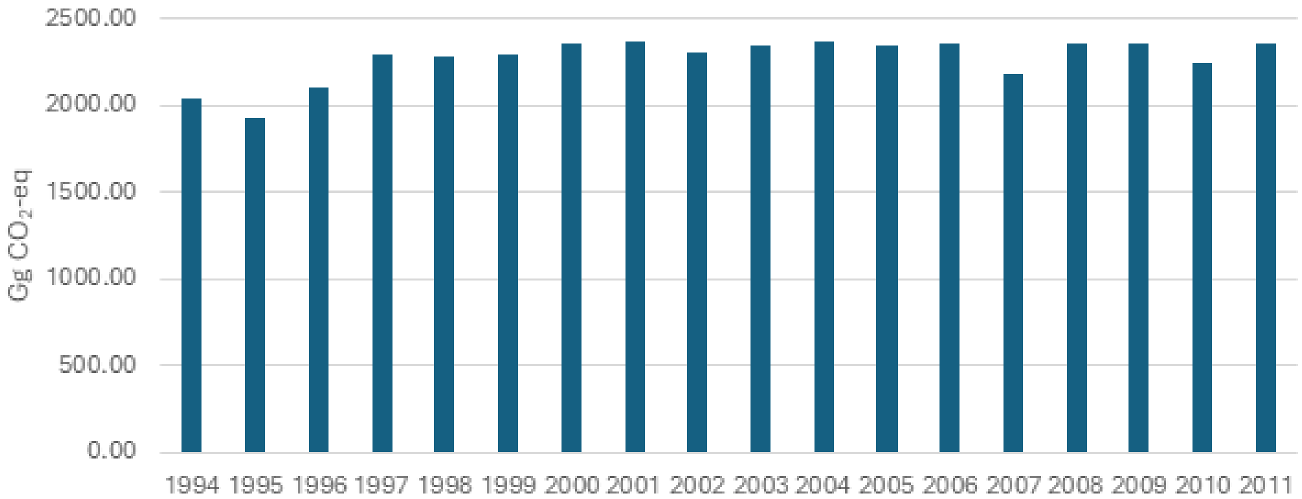


Figure 31: Methane emission from rice cultivation from the year 1994 to 2011

The comparisons from earlier inventories are presented in Table 27.

Table 27: Comparison of CH_4 emission calculation in different inventories over the years.

Categories	GHG Inventories			
	Current GHG emission (gGCH_4/ year) (in year 2022)	INC (July 2004)	SNC (in year 1994	TNC (in year 2011)
CH_4 emission (2011) (Gg)	84.19			159.00
CH_4 emission (2001) (Gg)	84.12		1.57	
CH_4 emission (1994/95) (Gg)	68.67	306		
% deviation from current emission		-345.61%	-98.35	
Remarks		EF, SF and CF and formula were different	EF, SF and CF and formula were different	Non flooded preseason >180 days (SF = 0.68 in current calculation but in TNC 1.22). SF for rainfed and irrigated condition also aggregated used while in current calculation disaggregated values for different areas and conditions used.

Direct and Indirect N_2O Emissions from Managed Soils

For the calculation of direct N_2O emission from managed soils and manure management, the methodologies and equations as stated in section 9.7.1 were applied. The direct N_2O emissions from managed soils for the years 1994 and 2011 are calculated to be 1037.778 (Gg 3.916 N2O per year) and 1385.977 (5.230 Gg N_2O) Gg CO_2-eq per year, respectively. The indirect N_2O emissions from atmospheric deposition from volatilization of N and from leaching and runoff from managed soils in 1994 and 2011 were calculated to be 411.920

(1.554 Gg N_2O) and 541.265 (2.043 Gg of N_2O) Gg CO_2-eq per year, respectively. Similarly, the indirect N2O emission from volatilization of manure management for the years 1994 and 2011 were calculated to be 25.123 (0.095 Gg N_2O) and 53.389 (0.201 Gg N_2O) Gg CO_2-eq per year, respectively. Figure 26 shows the graph for direct and indirect N_2O emissions from managed soils and manure management. It is observed that the N_2O emissions from these sources have been increasing over the years. Annex VIII.V has the calculated indirect N_2O emission for each year in gigagrams per year.

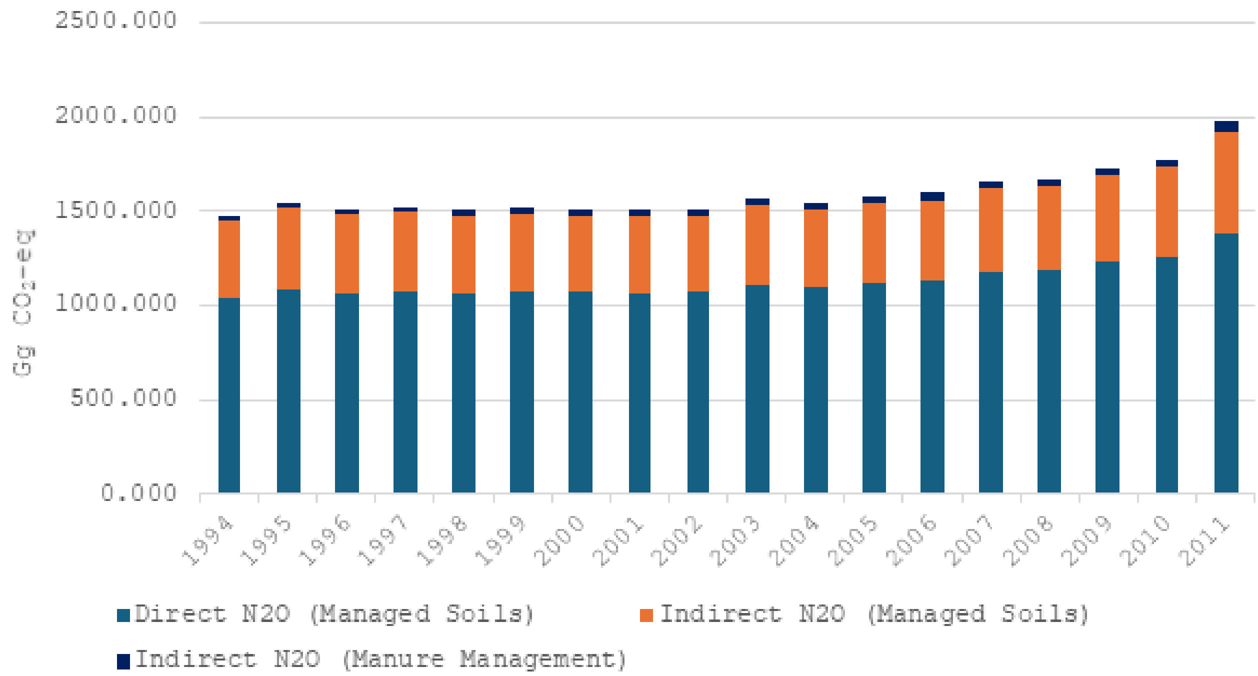


Figure 32: Direct and indirect N_2O emission in managed soils

For the year 2011 of the total emission within the sector the highest contribution was from rice cultivation (53.59%) followed by direct N_2O emission from managed soils (31.48%) while less than 15% were shared by other sources. Figure 33 shows the contribution of different sources within the sector for the year 2011.

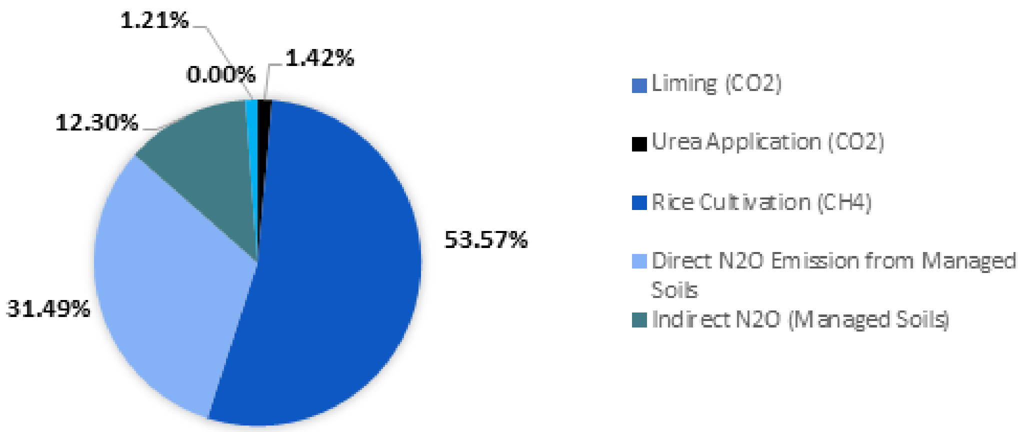


Figure 33: Contribution of different sources in emissions within the sector for the year 2022

3.8.3 Inventory of GHG emissions from 2012 to 2022

Urea application

The calculation of CO_2 emission from the urea application was done by applying the same method as for recalculation. The year-wise calculated CO_2 emission is in Annex VIII.V.. Figure 28 shows the CO_2 emissions from urea application from 2012 to 2022. The graph shows an increasing trend of emissions over the years for the increase in application of urea fertilizers to the soils.

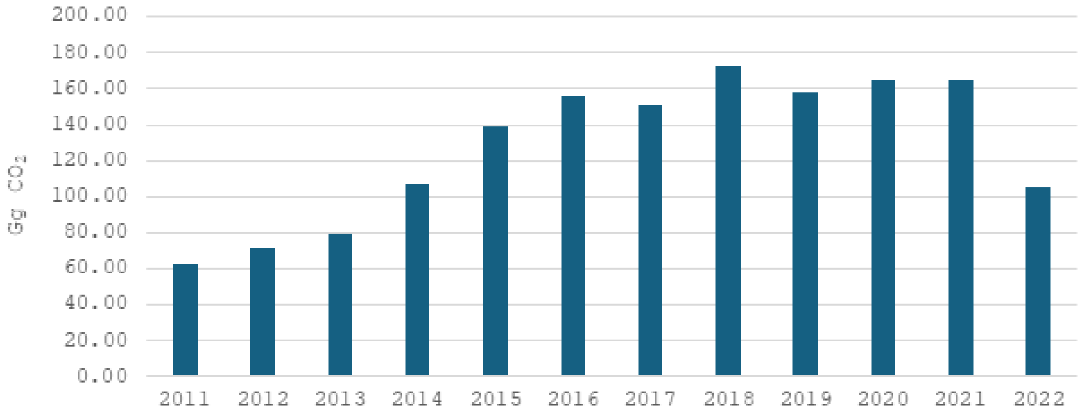


Figure 34: CO_2 emission from year 2012 to 2022 by urea application

Lime Application

The CO_2 emission due to application of lime in the agricultural soils in the year 2022 based on the data provided by AICL and assumptions made accounted to be 530.63 tonnes CO_2 per year. Figure presents the emission from liming from 2012 to 2022. The application of lime may be expected to increase over years as the soil is becoming more and more acidic, demanding more lime, thereby increasing the chances of contribution of liming in GHG emissions.

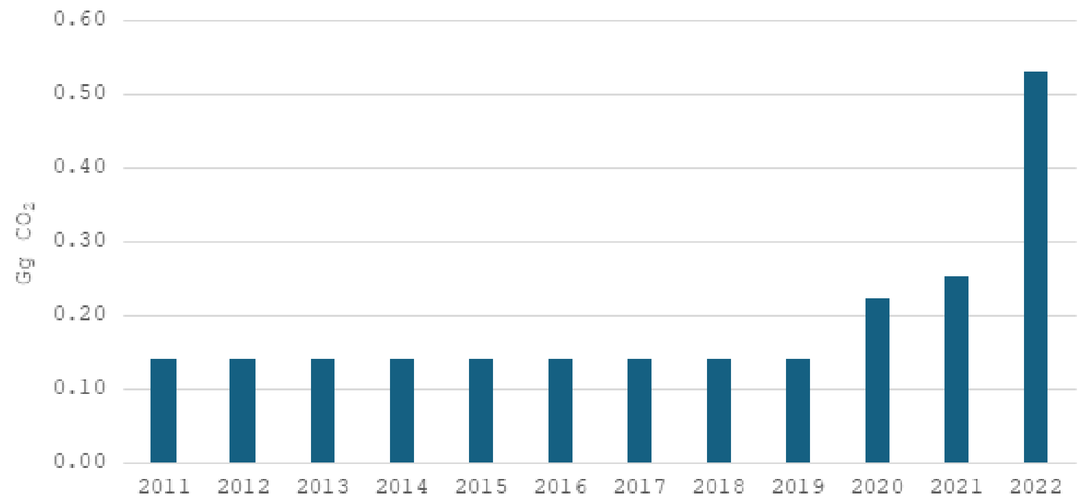


Figure 35: CO_2 emission from lime application from 2011-2022

Rice cultivation

The activity data (time series data on rice cultivation for these periods is in Annex VIII.I. While year-wise calculated gigagrams of CH_4 emission are in Annex VIII.V. Figure 36shows the CO_2 emission from the area application from 2012 to 2022. The harvested rice has remained more or less constant, except in some years, due to delayed monsoon and other impacts of climate change, reducing the total harvested area.

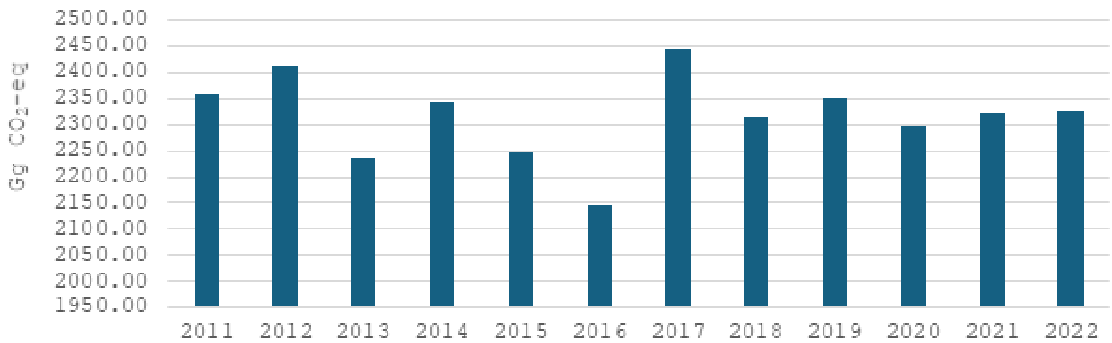


Figure 36: Methane emissions from rice cultivation from 2012-2022

Direct and indirect N_2O emissions from Managed Soils

The direct and indirect N_2O emissions for the year 2022 including emission from synthetic fertilizers, organic manures applied to managed soils and urine and dung deposited to pasture, range and paddock were calculated to be 1673.181 (6.314 Gg N_2O) and 682.552 (2.576 Gg N_2O) Gg CO_2-eq per year, while the indirect N_2O emission from manure management was 81.425 Gg CO_2-eq (0.307 Gg N_2O per year). The total N_2O emission for the year 2022 is calculated as 2437.157 Gg CO_2-eq, which is an increase of 18.12% compared to the year 2012. The direct and indirect N_2O emission calculated for the years 2012 to 2022 is shown in Figure 37. Annex VIII.V presents the year-wise calculation.

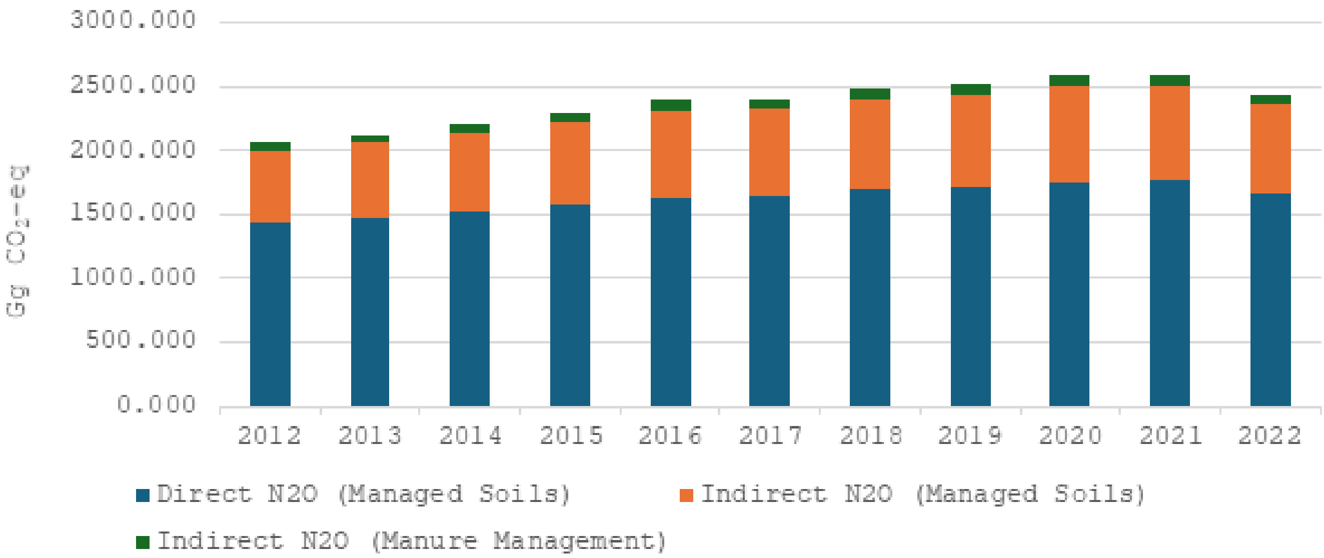


Figure 37: Direct and indirect N_2O emission from year 2012-2022

Table 28: Emission from Agriculture Sector in 2022

Categories	**Net emissions / removals**			
	CO_2	**CH_4**	**N_2O**	**Total**
	Gg	**Gg CO_2-eq**	**Gg CO_2 -eq**	**Gg CO_2 -eq**
3.C - Aggregate sources and non-CO_2 emissions sources on land	**105.751**	**2327.337**	**2437.157**	**4870.245**
3.C.2 - Liming	0.531			0.530627
3.C.3 - Urea application	105.220			105.2201
3.C.4 - Direct N_2O Emissions from managed soils			1673.181	1673.181
3.C.5 - Indirect N_2O Emissions from managed soils			682.552	682.552
3.C.6 - Indirect N_2O Emissions from manure management			81.425	81.425
3.C.7 - Rice cultivation		2327.337		2327.337

3.8.4 Uncertainty

The uncertainty for activity data related to the urea application and rice production area is estimated at 5%. The number of rice-growing days is assumed to range between 120 ± 5 days and 130 ± 10 days, while the proportion of irrigated and rainfed conditions may vary by ±5%. The combined impact of these variations, including changes in the harvested area under both irrigated and rainfed conditions and the number of growing days, results in an overall uncertainty of ±11.02%.

For the daily emission factor, the uncertainty ranges from -62.50% to +178.60% when considering the lowest and highest possible values for selected baseline emission factors, scaling factors, and conversion factors.

Although assumptions on private sector involvement in lime sales are made, the data may not fully represent all private sector contributions. Therefore, the uncertainty for lime application is assumed to be 20%.

The uncertainty for activity data for synthetic fertilizers (urea and DAP) and rice harvested area is ±5%, while the calculation of direct and indirect N_2O emissions from animal manure application to managed soils has considered ±20% uncertainty for the livestock population head data. The uncertainties for emission factors for calculating CO_2 emission from lime and urea application is -50%, total N excretion from livestock for calculating direct N_2O emission ranges from -75% to 208.51%, emission factor for calculating direct N_2O emissions from synthetic fertilizers and animal manure applied to rice and other croplands ranges from -100% to +223.61%, emission factor for calculating direct N_2O emission from urine and dung deposition to PPR ranges from -95.52% to 223.61% and the uncertainties of emissions factors for calculating indirect N_2O emission form atmospheric deposition from volatilization form managed soils ranges from -80% to +427.20 and for calculating indirect emission from leaching/runoff ranges from -74.75% to +286.74. The uncertainty for emission factors used for calculating indirect N_2O emissions from manure management ranged from -80% to 400% while the uncertainty for the activity remains same as for livestock population data.

3.8.5 Inventory Improvement Plans

Currently there are several data gaps and other challenges hindering in the development of a robust inventory. The following improvement plans are recommended for the development of strong inventories in the upcoming years.

Sector	Activities	
Liming	• Maintaining records of lime sales from PS + AICL • Keeping track of the types of lime used, such as dolomite, limestone, and other sources. • Deriving specific EFs	• Collecting data on the amount of lime applied to different land use systems/cropland (area). • Gather information on the rate of lime application through regular agricultural surveys.
Urea Application	• Keeping track of urea sales from PS/ agrovets, + AICL. • Collecting data on urea applied to different land use categories and cropland types (areas),	• Determining the average rate of urea application through agricultural surveys. • Determining specific EFs
Direct N_2O Emissions from Managed Soils	• Keeping records of livestock numbers, including detailed categories and subcategories • Determining different types of livestock manure managements in various regions • Collecting data on the number of livestock manure/ organic manure applied to croplands/land types (area) • Continuously monitoring NH_4 and NO_3 in soils. • Gathering detailed data on crop residues burning/ incorporation, cover crops incorporation and legumes integration (by surveys, remote sensing)	• Improving maps and classifications of land use and soil types to better reflect managed soils. • Incorporating sensors, drones, and process-based models to simulate N_2O emissions and track soil nitrogen and moisture levels. • Accounting for seasonal or yearly changes in fertilizer use, rainfall, and cropping patterns. • Conducting field experiments to measure N_2O emissions under varying soil, crop, managements. • Developing region-specific or crop-specific emission factors.

Indirect N_2O emissions from managed soils	• Determining region-specific EFs based on local research and field studies. • Establishing monitoring systems for N volatilization, leaching, and runoff using lysimeters, water sampling, and air-quality measurements under diverse agro-climatic conditions.	• Transitioning to models that simulate N dynamics, incorporating high-resolution data on soil properties, rainfall, and management practices. • Investing in centralized databases to track variability of N inputs, crop management practices, and environmental conditions.
Rice Cultivation	• Establish field monitoring systems using flux chambers and advanced sensors to measure CH_4 emissions across diverse rice-growing regions and management practices. • Develop and apply EFs tailored to local conditions (e.g., water management, soil type, organic inputs)	• Disaggregating Activity Data – (irrigation regimes - continuous flooding, alternate wetting and drying; organic residue incorporation; cropping intensity)

3.9 Land Use, Land Use Change and Forestry

Nepal covers an area of 14,751,600 hectares, with approximately 46.1% of this land under forest cover. The Land Use, Land Use Change, and Forestry (LULUCF) sector is vital for the country's environmental sustainability and economic development. It plays a dual role by helping mitigate climate change through carbon sequestration while supporting livelihoods, preserving biodiversity, and regulating water resources. However, human activities such as deforestation, land degradation, and unsustainable agricultural and grazing practices pose significant challenges to this sector. These pressures contribute to environmental degradation, including increased greenhouse gas emissions and reduction in the capacity for carbon sequestration, threatening Nepal's overall ecological balance.

In response to these challenges, Nepal has developed a comprehensive framework of policies, strategies, and institutions at both the national and local levels, specifically aimed at addressing key areas within the Land Use, Land Use Change, and Forestry (LULUCF) sector. These frameworks demonstrate Nepal's commitment to mitigating climate risks while promoting a resilient, low-carbon economy.

This section focuses on the greenhouse gas (GHG) emissions (and removals) of CO_2 occurring in managed ecosystems. It examines emissions from land (IPCC category 3.B) caused by activities such as deforestation, forest degradation, afforestation/reforestation, and the sustainable management of forests. Changes in land use for non-forest categories have also been considered. As a result, emissions from the land category have been analyzed across six land representations:

3.B.1 - Forestland

3.B.2 - Cropland

3.B.3 - Grassland

3.B.4 - Wetland

3.B.5 - Settlement

3.B.6 - Other Lands

This section has been prepared in accordance with decision 18/CMA.1, which outlines the Modalities, Procedures, and Guidelines (MPGs) for the transparency framework under Article 13 of the Paris Agreement. It includes comprehensive data collection, uncertainty assessments, key category analysis, methodological choices, recalculations, and processes for quality control and quality assurance.

This report covers only the CO_2 emissions/removals based on the (a) Forest remaining forest and land use converted to the forest (b) Cropland remaining cropland and land converted to cropland (3) Grassland remaining grassland and land use converted to grassland and (4) settlement remaining settlements and land use converted to settlements. Emissions/removals of CO_2 were calculated for each of these categories. Figure 32 below illustrates the categories and subcategories applied during the inventory process, while Figure 33 shows the specific subcategories used in the IPCC software. The CO_2 emissions/removals for this sector were estimated using the Tier 1 approach, with data sourced from the National Land Cover Monitoring System (NLCMS), as shown in Table 29.

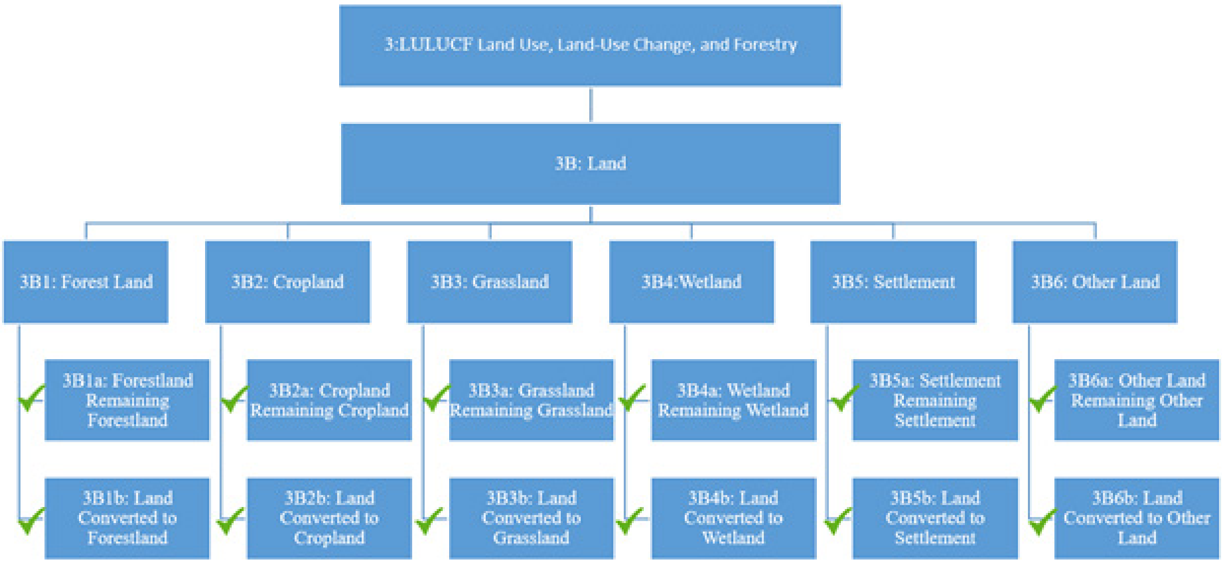


Figure 38: Included categories for the GHG inventory

3.9.1 Description of Land Use, Land Use Change and Forestry Sector in Nepal

The forestry and land-use sector plays a critical role in Nepal's GHG inventory, contributing both emissions and significant carbon removals. Forests act as major carbon sinks, absorbing substantial amounts of CO_2 through photosynthesis. However, deforestation, degradation, and land-use change released carbon as CO_2, contributing to GHG emissions. As highlighted in IPCC reports, an estimated 23% of total anthropogenic GHG emissions (2007-2016) derive from agriculture, forestry and other land use (AFOLU) (IPCC 2019). This underscores the importance of effective forest management and conservation in mitigating these emissions. To comply with UNFCCC requirements and accurately report GHG inventories, including those from AFLOU, it is crucial to monitor forest cover, carbon stocks, and land-use changes. This section provides information on these sectors, following IPCC guidelines to ensure transparency, accuracy, and completeness.

The main datasets used in LULUCF include (a) land use representations for each sub-category and (b) a land use change matrix (representing transitions in land use) generated through national land cover monitoring systems. The land use maps from 2002 to 2022 were downloaded, and the change matrix was prepared using Python. The information derived from the land use data was verified through expert judgment. The data generation process involved a thorough QA/QC procedure, both internally and externally, and included documentation of the processes involved in generating the activity data. Table 29 shows the data sources used in this report.

Table 29: Data sources and GHGs calculated (National Land Cover Monitoring System)

Category	GHGs	Method
Forest Land	CO_2	T1
Cropland	CO_2	T1
Grassland	CO_2	T1
Wetland	CO_2	T1
Settlement	CO_2	T1
Other Land	CO_2	T1

vv3.9.2 Methodology

The methods and assumptions are used to categorize land use/land cover classes, generate activity data, and apply emission factors for the LULUCF sector. The inventory follows the 2006 IPCC guidelines, specifically in terms of data identification and selection, methodologies, and the use of emission factors. In cases where data were limited, expert judgment and underlying assumptions were applied consistently and transparently. Nepal has implemented a national land cover monitoring system, with land cover maps available from 2002 to 2022. The system classifies land into 11 classes, and importantly, the NLCMS report provides guidance on which classes can be merged and categorized under the IPCC land cover classes Table 30. The values generated for each land class in each year were processed using IPCC software to calculate the GHGI. Due to the unavailability of land use data for 2012 and issues with the 2008 land use map, linear interpolation was applied to fill the gaps. Emission estimates in this report were generated using Tier 1 method, depending on the availability of data.

Table 30: Land cover classes, definition and IPCC value (NLCMS report)

NLCMS land cover value	Main land cover class	Description	IPCC land cover class	IPCC value
4	Forest	Land spanning more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 10%, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use.	Forest land	1
11	Other Wooded land (OWL)	Land is not classified as forest spanning more than 0.5 ha, having at least 20 m width and a tree canopy cover of trees between 5% and 10%. The canopy cover of trees is less than 5% but the combined cover of shrubs, bushes and trees is more than 10%; including areas of shrubs and bushes where no trees are present.	Forest land	1
10	Grassland	Areas covered by herbaceous vegetation with cover ranging from Closed to Open (15–100%). This category includes rangeland and pasture that is not considered cropland.	Grassland	3
7	Cropland	This category includes arable and tillage land, and agroforestry systems where vegetation falls below the thresholds used for the forest land category, consistent with the selection of national definitions.	Cropland	2
6	Built-up area	Built-up areas refer to artificial structures such as towns, villages, industrial areas, airports, etc.	Settlement	5
1	Waterbody	Rivers are natural flowing water bodies and typically have elongated shapes. Lakes and ponds are perennial standing water bodies.	Wetland	4
5	Riverbed	A tract of land without vegetation surrounded by the waters of rivers, streams & lakes usually includes any accretion in a river course.	Wetland	4
8	Bare soil	A soil surface devoid of any plant material.	Other	6

9	Bare rock	Non-vegetated areas with a rock surface.	Other	6
3	Snow	This class describes perennial snow (persistence > 9 months per year).	Other	6
2	Glacier	Perennial ice in movement.	Other	6

- Land representation approaches

Nepal used approach 1 for the land use representation, which enabled the tracking of land use changes within and between specific land use categories. Annual matrices were developed to document both land that remained unchanged and land that underwent conversion during the period from 2002 to 2022. This data was then utilized to create the land representation matrix Annex IX.I for input into the IPCC software.

- Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

Nepal implemented approach 1 for land representation, assessing both net gains and losses in land use. This method tracked areas that remained within the same land use category and those that transitioned between categories. The representation incorporated top-level land use categories, further subdivided to address national circumstances critical for estimating emissions and removals, as outlined in the 2006 IPCC guidelines. These sub-categories were analyzed to ensure robustness in emissions and removal estimations, representing the various ecological regions of the country and ensuring comprehensive reporting. To input the data into the IPCC software, the entire country was treated as a single climate region (tropical montane) with one soil type of High Activity Clay Mineral Soil, as per Table 3.1 of the 2006 IPCC Guidelines.

Land representation data was generated annually for each sub-category, capturing both land that remained unchanged and land conversions throughout the reporting period. In the forestry sector, the primary sources of greenhouse gas (GHG) emissions—predominantly carbon dioxide (CO_2) arise from land transitions such as conversion to agriculture, grassland, or settlements. While CO_2 is the main GHG in this sector, other gases like methane (CH_4) and nitrous oxide (N_2O) can be emitted from biomass burning; and methane (CH_4).

3.9.3 Activity data

The data collection for the forestry sector involved the development of a land use change matrix utilizing land cover maps from Nepal's National Land Cover Monitoring System (NLCMS)(MoFE, 2024). The NLCMS provides comprehensive land cover information spanning from 2002 to 2022. However, a land cover map for the year 2012 was unavailable. To address this gap, linear interpolation was employed to estimate the land cover change matrix for the missing year, ensuring data continuity. Subsequently, information on forest land subcategories, including natural forests and plantation forests, was compiled. The State of Nepal's Forests Report (DFRS, 2015) served as a primary data source up to 2015, supplemented with additional records from relevant divisions and departments. Any missing years' data were interpolated to maintain consistency across the timeline.

Forest fire data was sourced from FAOSTAT (FAO, 2024), with relevant information for Nepal carefully extracted, categorized, and incorporated into the analysis. Data on forest growing stock were derived from successive forest resource inventories conducted in 1994 and 2010–2014, supplemented by secondary data from credible sources to ensure completeness and accuracy.

Emissions/removals of CO_2 were calculated for each of these categories. Figure 33 shows the specific subcategories used in the IPCC software. The CO_2 emissions/removals for this sector were estimated using the Tier 1 approach, with data sourced from the National Land Cover Monitoring System (NLCMS), as shown in Table 30.

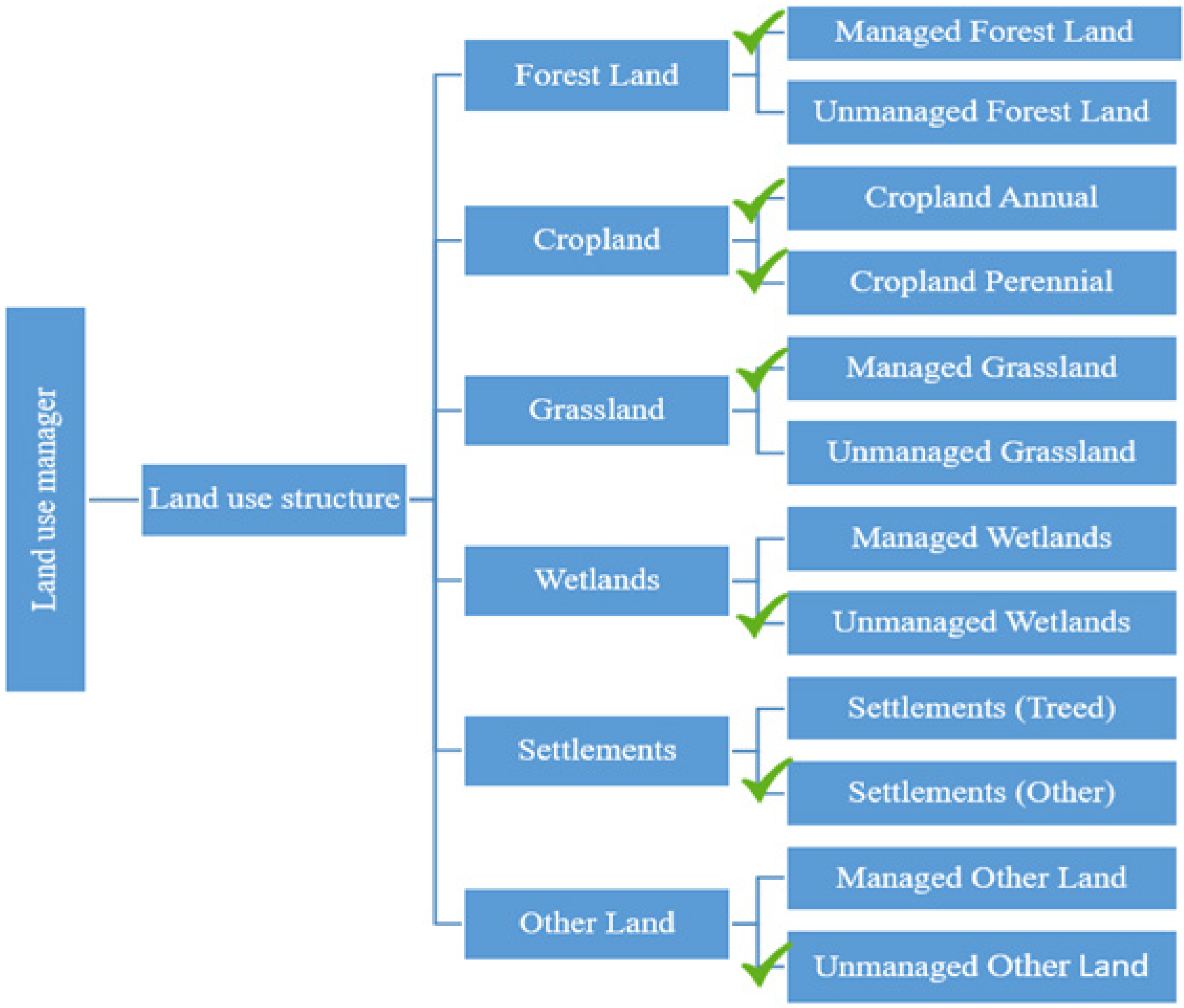


Figure 39: Categories and sub-categories applied in IPCC software

Description of flexibility applied

In the LULUCF sector, Nepal has applied several flexibility measures due to challenges related to data availability and the limitations of existing monitoring systems. These flexibility measures include the following:

- Land Use Change Matrix: The information used to construct the land use change matrix has been derived from the NLCMS. This system provides a comprehensive overview of land cover changes, although certain data gaps have necessitated the application of a supplementary method.
- Interpolation of Land Use Maps: There were issues identified with the 2008 land use map, leading to the need for linear interpolation to address these discrepancies. Additionally, for the year 2012, no land use map was available. As a result, linear interpolation was again applied to estimate land use changes for that year.
- Forest Data Limitations: Nepal faces significant data gaps in the forestry sector, including the absence of comprehensive data on forest fire areas. Due to the lack of this specific information, readily available data from the FAO Stat database was used as a substitute to estimate the areas affected by forest fires.
- General Database Challenges: The overall lack of a robust database in the forestry sector, combined with limitations in data collection and monitoring infrastructure, has necessitated the use of flexible approaches. This includes reliance on international datasets and interpolated estimates to ensure continued reporting in line with the UNFCCC requirements.

3.9.4 Emission Factor

The emission factor used for the GHG inventory for Land use and Forestry sector is presented in the Annex IX.II.

3.9.5 GHG trends in this sector

GHG emissions and removals were reported from forestland, cropland, grassland, and settlements. Using Approach 1, emission data for wetlands and other land types were unavailable. The general trend for removals in the forestry sector has been increasing throughout the reporting period, which is linked to management practices and government priorities aimed at improving the country's forest cover. In contrast, emissions from cropland have been steadily increasing, while emissions from grassland have shown both increases in certain years and decreases in Figure 40.

The analysis indicates that the forestry sector has been a net remover, with an estimated average removal of 13,889.7 Gg CO_2-eq per year from 2002 to 2022. Similarly, emissions from cropland averaged an estimated 2,060.08 Gg CO_2-eq over the same period. Interestingly, the settlement sector also showed removals, peaking in 2018, with an unrealistic trend observed in 2022. The grassland sector emitted an average of 2,467.57 Gg CO_2-eq during this period, with only removal occurring in 2022.

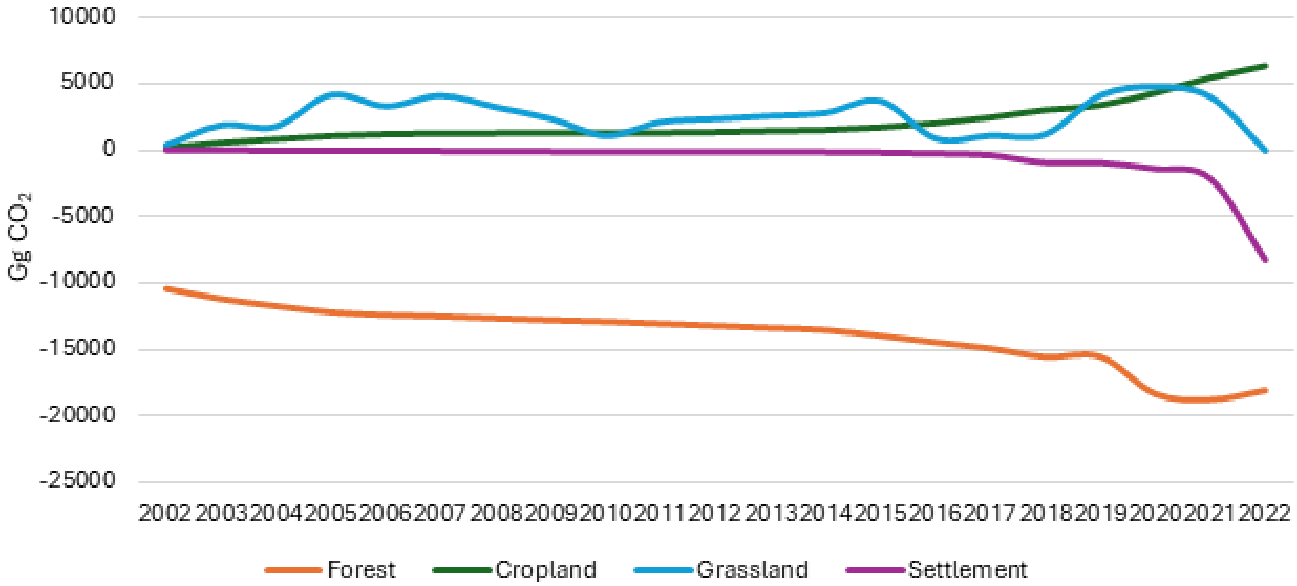


Figure 40: LULUCF sector emission trend

3.9.6 Recalculation from 1994-2011 for LULUCF

The national land cover map has been available since 2002 on the NLCMS website. Since recalculations are required back to 1994, a backward linear projection was applied for all land classes to estimate the data for earlier years. For forest fire emissions, the data were accessed directly from the FAO Stat database, which provides information starting from 1990.

The recalculation of LULUCF emissions and removals from 1994 to 2011 across four land use categories: Forest Land, Cropland, Grassland, and Settlement, is presented in Figure 41. The values represent emissions and removals, where negative values indicate carbon removals (i.e., carbon sequestration) and positive values represent emissions. For Forest Land, the consistently negative values from 1994 to 2001 (around -13063 Gg CO_2) suggest a significant and stable level of carbon sequestration through forest growth or preservation. From 2002 onwards, the negative values decreased gradually, indicating that carbon sequestration in forests has been reduced, with emissions increasing slightly due to deforestation or forest degradation.

In Cropland, emissions start at zero and then gradually increase from 2002 onward, with the highest emissions in 2005, reflecting land-use changes and possible shifts in farming practices, such as intensification or land conversion. Grassland shows a similar trend, with emissions fluctuating over the years, peaking in 2005 at over 1073 Gg CO_2, which may indicate changes in land management practices or land use conversions to other forms of land cover.

For Settlement, the values are consistently negative, indicating carbon removal (possibly through urban greening, afforestation, or the transformation of land into built-up areas), but the level of removal decreases over time, with a steady increase in the values becoming less negative. Overall, the recalculation reflects the changes in land use and land management practices over time, showing that forests and grasslands have been net carbon sinks in earlier years, with emissions rising in later years due to deforestation and land conversion for agriculture and settlement expansion.

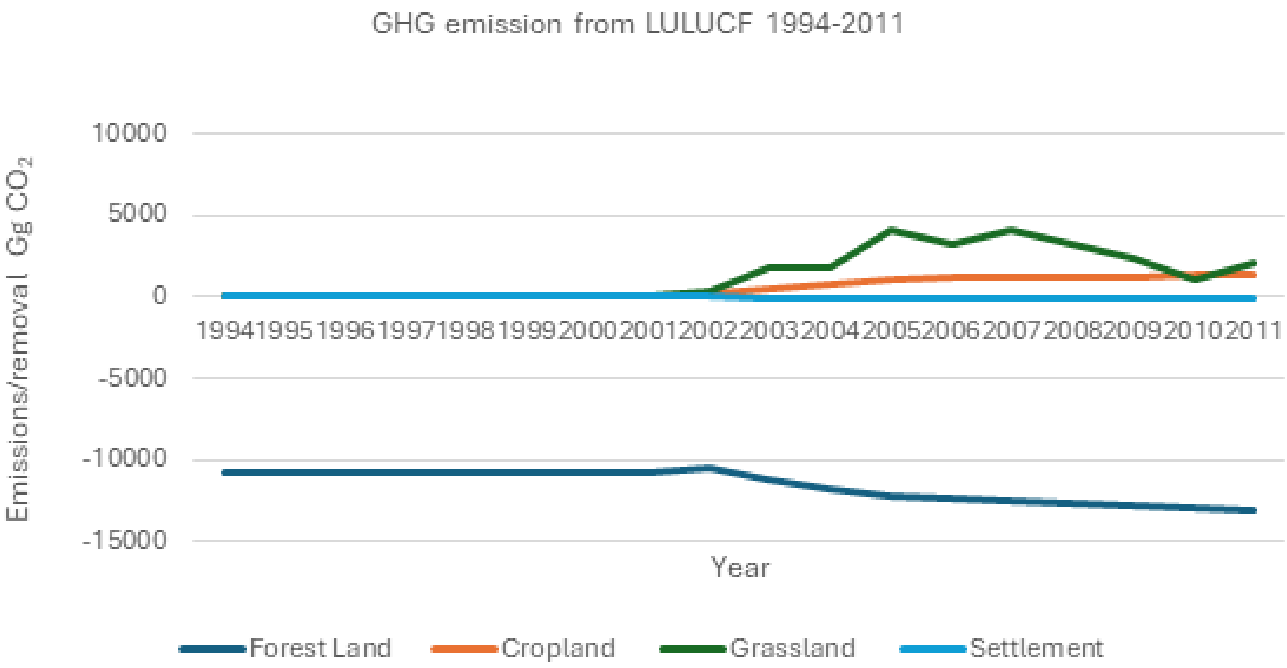


Figure 41: Recalculation of GHG emission/removal from 1994-2011 for LULUCF

The recalculation of emissions from 2001 to 2011 is compared with the Third National Communication (TNC), showing a noticeable difference. The only similarity between the two is the increasing trend in carbon sequestration from the forestry sector. In 2001, the sequestration in this recalculation is higher compared to the TNC, which reported a sequestration of -10,500 Gg. However, in 2011, the TNC reported a higher level of CO_2 sequestration (-17,077.81 Gg) compared to this recalculation, which showed -13,063.10 Gg. The discrepancy in the rate of improvement between the TNC and this recalculation suggests that different methodologies or assumptions were used in data analysis. For non-forest sectors, emissions in 2011 were positive, indicating carbon release. TNC reported emissions of 35.39 Gg, while this report shows significantly higher emissions of 3,279.11 Gg. This contrast again highlights methodological differences, as the TNC accounts solely for non-forest land, whereas the report includes a broader range of land categories, such as cropland, grassland, settlements, wetlands, and others.

Table 31: Forest and Non-Forest GHG emissions and removal (Gg) (TNC vs. NIR, 2001–2011)

S.N		Year	Emissions (TNC)	Emissions (NIR)
1	Forest	2001	- 10500	-10791.4938
2		2003	-11800	-11201.0355
3		2005	-13200	-12194.2854
4		2007	-14500	-12512.9261
5		2009	-15700	-12801.0747
6		2011	-17077.81	-13063.0981
7	Non-forest	2011	35.39	3275.108

3.9.6.1 Forest Fire

For the recalculation of emissions due to forest fires, data for three greenhouse gases (GHGs) were considered. However, CO_2 data is only available from 2000 onwards. Therefore, a combined CO_2-eq for CH_4 and N_2O is presented in one Figure 42, while CO_2 emissions are displayed separately in another Figure 37.

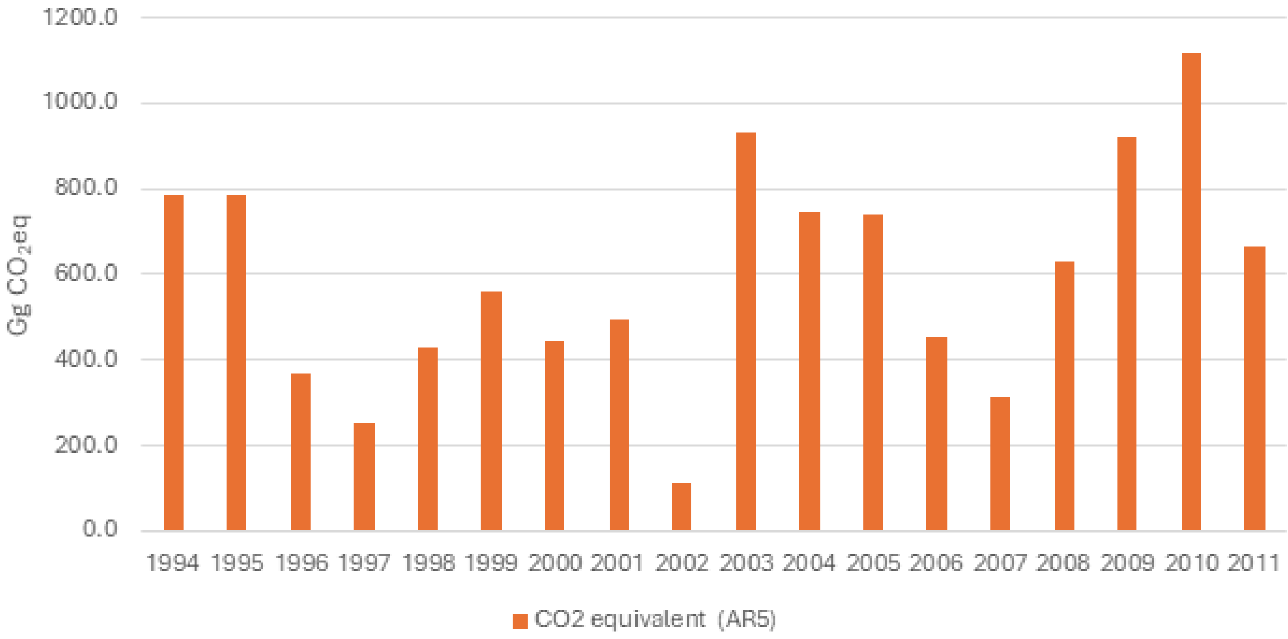


Figure 42: CO_2 equivalent emissions (CH_4 and N_2O) from forest fires

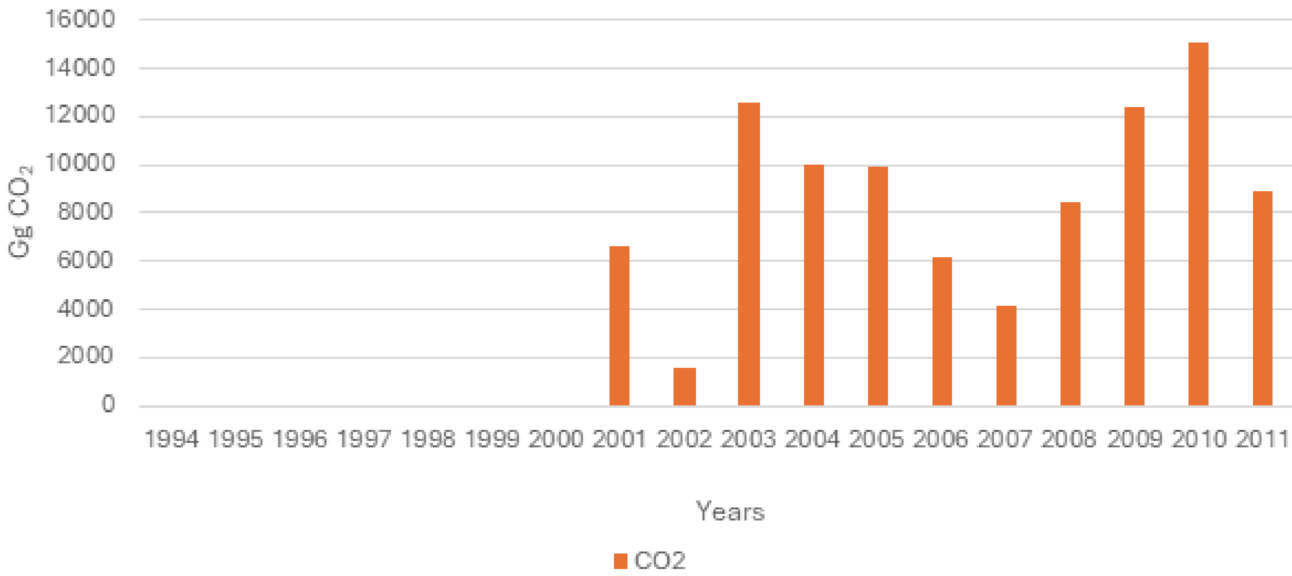


Figure 43: CO_2 equivalent emissions from forest fires

CH_4 and N_2O emissions are recorded throughout the period, while CO_2 emissions are available only from 2001 onward. Methane (CH_4) emissions range from a high of 17.9 Gg in 2003 to a low of 2.2 Gg in 2002, showing variability across the years. Similarly, N_2O emissions fluctuated between 2.0 Gg in 2010 and 0.2 Gg in multiple years, including 1997 and 2002. CO_2 emissions, beginning in 2001, exhibit a general upward trend, peaking at 15,021.15 Gg in 2010, followed by a slight decrease to 8,913.85 Gg in 2011. This data highlights distinct emission patterns for each greenhouse gas, with CO_2 increasing more after its initial recording in 2001, potentially indicating escalating forest fire impacts or improved recording mechanisms over time.

3.9.7 Inventory development 2012-2022 for LULUCF

3.9.7.1 Forest Land

Emissions in this category have been reported for stable land, forestland, remaining forestland, and for land converted to forestland from other classes. Overall, the forestland category shows an increasing trend in sequestration, measured in gigagrams of CO_2 equivalent, rising from 13,220.32 Gg CO_2-eq in 2012 to 18,072.10 Gg CO_2-eq in 2022, as illustrated in Figure 38.

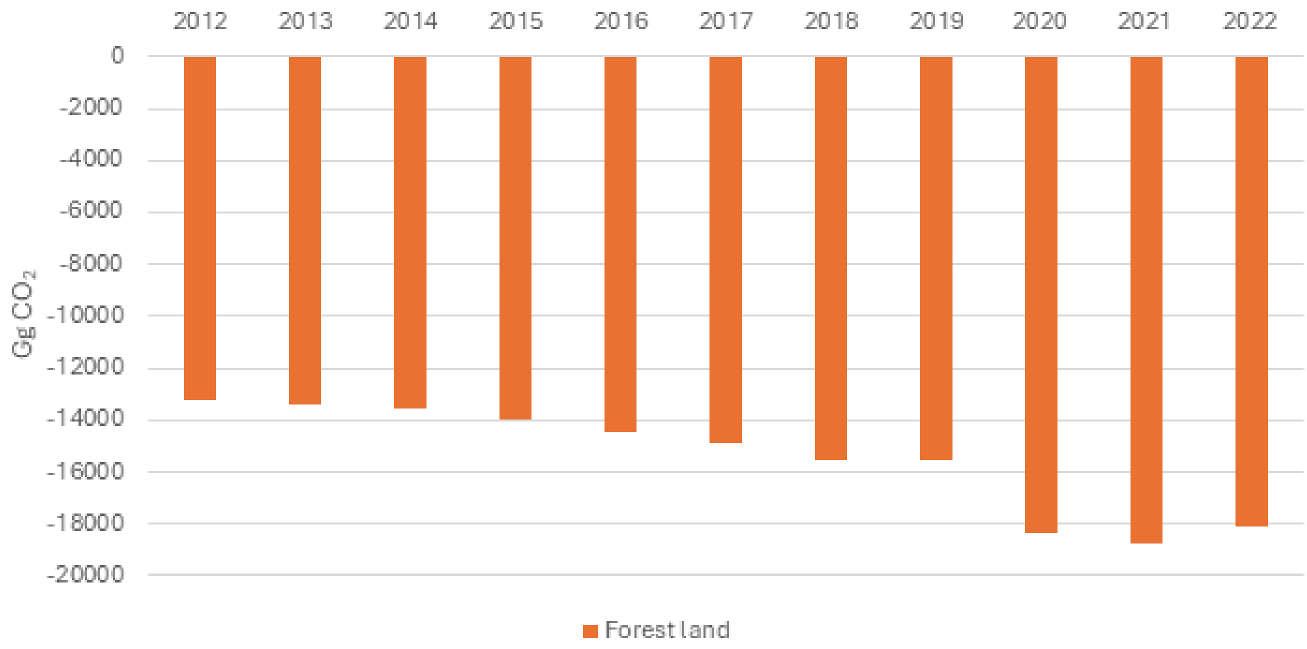


Figure 44: GHG sequestration from forest land

3.9.7.2 Cropland

Similar to the forest land, for this category cropland remaining cropland and other land converted to cropland is calculated. This category showed that emissions are in an increasing trend from 1346.68 Gg CO_2-eq to 6345.51 Gg CO_2-eq from 2012 to 2022 as shown in Figure 45.

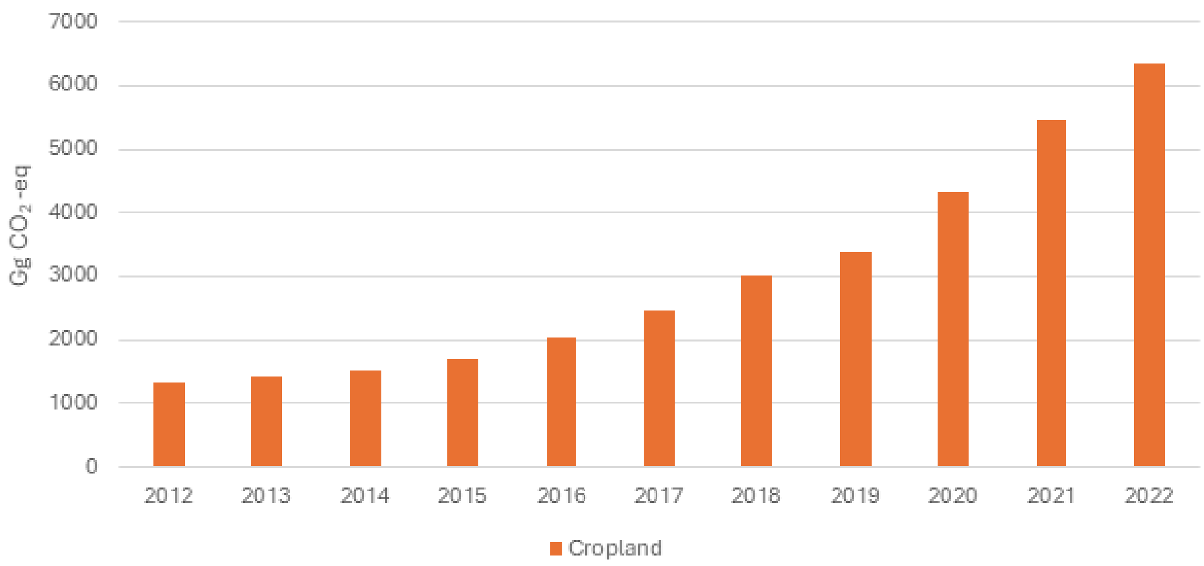


Figure 45: Emissions from Cropland

3.9.7.3 Grassland

This category includes both remaining grasslands and other land converted to grassland. When comparing emissions from 2012 to 2022, there has been an overall increase, though emissions fluctuated from year to year. From 2012 to 2015, emissions rose steadily from 2,345.285 Gg CO_2 to 3,698.237 Gg CO_2. However, in 2016, emissions dropped to 871.491 Gg CO_2, with a slight increase to 1,196.18 Gg CO2 in 2018. In 2019, emissions peaked at 4,127.99 Gg CO2, followed by a rise to 4,771.51 Gg CO_2 in 2020. In 2021, emissions decreased to 4,005.21 Gg CO_2. The inventory analysis from 2012 to 2021 shows the overall trend in GHG emissions, while for 2022, 38.8 Gg CO_2 was sequestered, as illustrated in Figure 46.

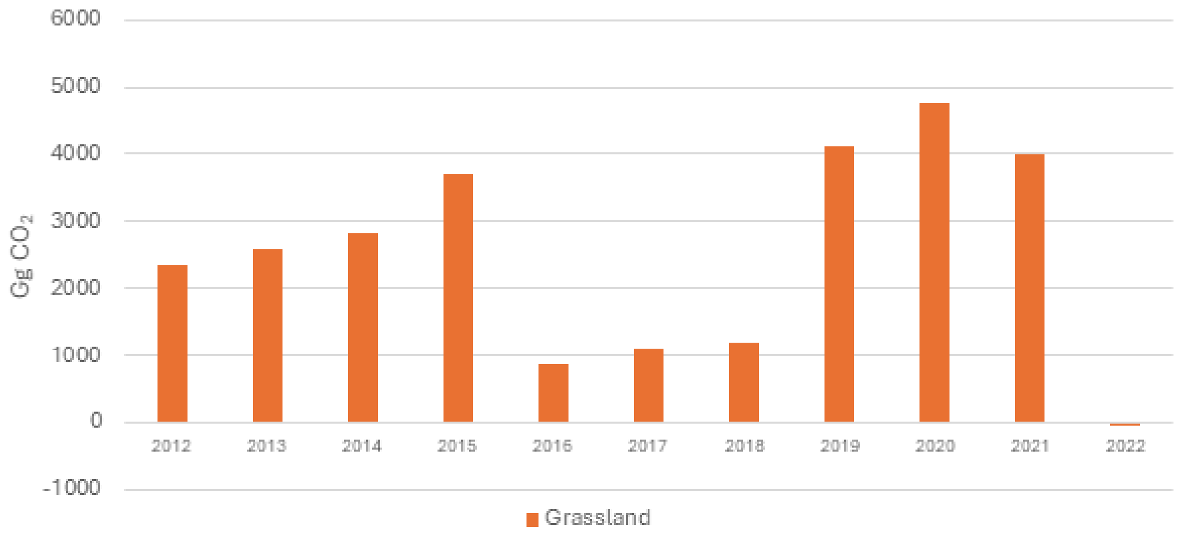


Figure 46: Emissions/Removals from grassland

3.9.7.4 Settlements

The analysis for settlements includes both remaining settlements and other land converted to settlements, calculated for each year from 2012 to 2022. The results revealed that settlements are acting as a sink for GHG emissions in the context of Nepal. The trend shows a steady increase, starting from 143.54 Gg CO_2 in 2012 and rising to 8,256.5 Gg CO_2 in 2022, as shown in Figure 47.

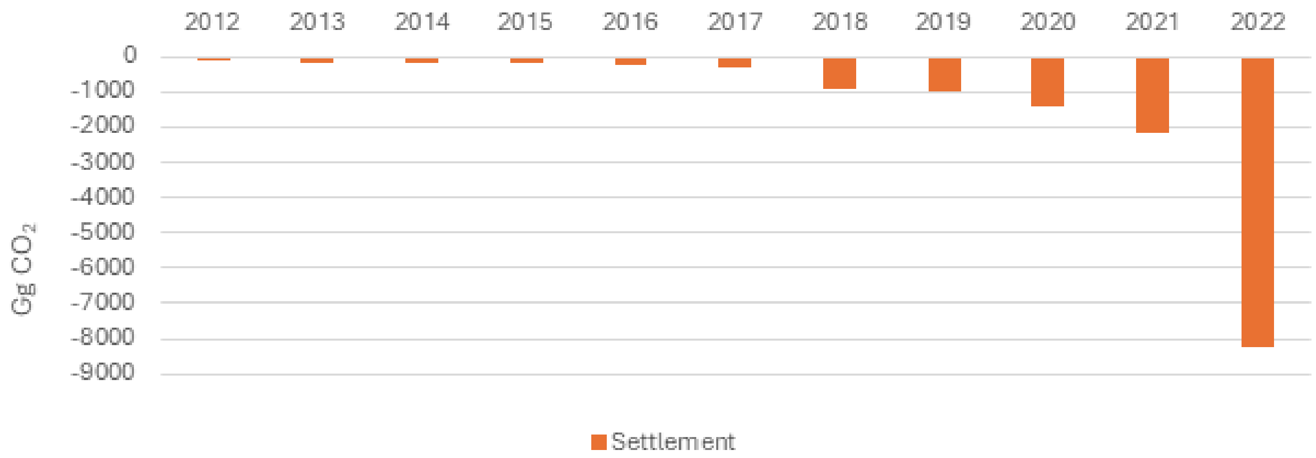


Figure 47: Emissions/Removal from settlement category

Table 32: Emission from Forestry and Land Use sector in 2022

Categories	Net CO_2 emissions / removals			
	CO_2	CH_4	N_2O	Total
	Gg	Gg CO_2-eq	Gg CO_2-eq	Gg CO_2-eq
3.B - Land	**-20021.958**			**-20021.958**
3.B.1 - Forest land	-18072.100			-18072.100
3.B.1.a - Forest land Remaining Forest land	-18072.100			-18072.100
3.B.1.b - Land Converted to Forest land	-			-
3.B.1.b.i - Cropland converted to Forest Land	-			-

3.B.1.b.ii - Grassland converted to Forest Land	-			-
3.B.1.b.iii - Wetlands converted to Forest Land	-			-
3.B.1.b.iv - Settlements converted to Forest Land	-			-
3.B.1.b.v - Other Land converted to Forest Land	-			-
3.B.2 - Cropland	6345.516			6345.516
3.B.2.a - Cropland Remaining Cropland	6345.516			6345.516
3.B.2.b - Land Converted to Cropland	-			-
3.B.2.b.i - Forest Land converted to Cropland	-			-
3.B.2.b.ii - Grassland converted to Cropland	-			-
3.B.2.b.iii - Wetlands converted to Cropland	-			-
3.B.2.b.iv - Settlements converted to Cropland	-			-
3.B.2.b.v - Other Land converted to Cropland	-			-
3.B.3 - Grassland	-38.794			-38.794
3.B.3.a - Grassland Remaining Grassland	-38.794			-38.794
3.B.3.b - Land Converted to Grassland	-			-
3.B.3.b.i - Forest Land converted to Grassland	-			-
3.B.3.b.ii - Cropland converted to Grassland	-			-
3.B.3.b.iii - Wetlands converted to Grassland	-			-
3.B.3.b.iv - Settlements converted to Grassland	-			-
3.B.3.b.v - Other Land converted to Grassland	-			-
3.B.4 - Wetlands	-			-
3.B.4.a - Wetlands Remaining Wetlands	-			-
3.B.4.a.i - Peat Extraction remaining Peat Extraction	-			-
3.B.4.a.ii - Flooded Land remaining Flooded Land	-			-
3.B.4.b - Land Converted to Wetlands	-			-
3.B.4.b.i - Land converted for Peat Extraction	-			-
3.B.4.b.ii - Land converted to Flooded Land	-			-
3.B.5 - Settlements	-8256.580			-8256.580
3.B.5.a - Settlements Remaining Settlements	-8256.580			-8256.580
3.B.5.b - Land Converted to Settlements	-			-
3.B.5.b.i - Forest Land converted to Settlements	-			-
3.B.5.b.ii - Cropland converted to Settlements	-			-
3.B.5.b.iii - Grassland converted to Settlements	-			-

3.B.5.b.iv - Wetlands converted to Settlements	-			-
3.B.5.b.v - Other Land converted to Settlements	-			-
3.B.6 - Other Land	-			-
3.B.6.a - Other land Remaining Other land	-			-
3.B.6.b - Land Converted to Other land	-			-
3.B.6.b.i - Forest Land converted to Other Land	-			-
3.B.6.b.ii - Cropland converted to Other Land	-			-
3.B.6.b.iii - Grassland converted to Other Land	-			-
3.B.6.b.iv - Wetlands converted to Other Land	-			-
3.B.6.b.v - Settlements converted to Other Land	-			-
3.C - Aggregate sources and non-CO_2 emissions sources on land	-			
3.C.1 - Burning	-	-	-	-
3.C.1.a - Burning in Forest Land	-	-	-	-
3.C.1.b - Burning in Cropland	-	-	-	-
3.C.1.c - Burning in Grassland	-	-	-	-
3.C.1.d - Burning in all other land uses	-	-	-	-
3.D - Other	-	-	-	-
3.D.1 - Harvested Wood Products	-	-	-	-
3.D.2 - Other (please specify)	-	-	-	-

3.9.8 Uncertainty assessment and time-series consistency

The uncertainty primarily arises from challenges related to data availability, quality, and the methodologies used. One key issue is the lack of comprehensive and consistent forest inventory data, particularly on forest fires, which has led to an increased level of uncertainty in emission and removal estimates. For some years, the use of interpolation methods, such as linear interpolation for the 2008 and 2012 land use maps, has been necessary to address data gaps, further contributing to uncertainty. Additionally, the application of default emission factors from international sources like the FAO introduces some level of uncertainty, as these may not fully capture the specific conditions in Nepal's forests and land use dynamics.

The uncertainty assessment for the LULUCF was carried out using the uncertainty values provided in the IPCC Guidelines, specifically in Volume 4, Chapter 4. This assessment covered Forest Remaining Forest, considering biomass, dead organic matter, and soil carbon for the years 2012 and 2022. The total uncertainty (U) was calculated by applying the formula:

This same approach was applied to the Cropland sector, using the relevant uncertainty values from Volume 4, Chapter 5 of the IPCC Guidelines. The assessment for Cropland Remaining Cropland also considered biomass, dead organic matter, and soil carbon for the years 2012 and 2022, and the total uncertainty for each year was determined using the same formula. Similarly, the uncertainty assessment for Grassland was conducted with reference to the uncertainty values in Volume 4, Chapter 6. This assessment covered Grassland Remaining Grassland, addressing biomass, dead organic matter, and soil carbon for the years 2012 and 2022. Again, the uncertainty for each year was calculated using the same formula. Lastly, for the Settlement sector, the uncertainty assessment followed the methodology outlined in Volume 4, Chapter 8 of the IPCC Guidelines, focusing on Settlement Remaining Settlement, and covering biomass, dead organic matter, and soil carbon for the years 2012 and 2022. The total uncertainty (U) for these years was also calculated using the same formula. The Table 28 presents the uncertainty values for both emission factors and activity data across different land use categories. For Forest Remaining Forest (FL), the uncertainty in emission factors is ±50, while activity data uncertainty is significantly higher at ±90. In the case of Cropland Remaining Cropland (CL), emission factor uncertainty is ±75, with activity data uncertainty at ±50.99. For Grassland Remaining Grassland (GL), the uncertainty in emission factors is relatively low at ±6, but activity data uncertainty is high at ±100. Lastly, for Settlement Remaining Settlement (SL), there is no uncertainty in emission factors (0), while activity data uncertainty is ±50. These values indicate that uncertainty levels vary considerably across land use categories, with activity data generally exhibiting higher uncertainty than emission factors.

Table 33: Uncertainty analysis for emission factor and activity data Uncertainty Analysis

	Emission Factor Uncertainty	Activity data Uncertainty
FL remaining FL	±50	±90
CL remaining CL	±75	±50.99
GL remaining GL	±6	±100
SL remaining SL	0	±50

To maintain time-series consistency, Nepal has made efforts to apply consistent methodologies and data sources across the reporting period from 2012 to 2022. However, due to data limitations, adjustments were necessary to ensure comparability over time. For example, linear interpolation was used for the years 2008 and 2012 in the absence of available land use maps, ensuring temporal continuity despite potential inaccuracies in these years. Efforts to apply consistent estimation methods, such as using default emission factors from the IPCC guidelines and relying on FAO data for forest fire areas, have been made, although variations in methods across years may occur as national capacities improve and data availability increases.

3.9.9 Category specific QA/QC and verification

The QA/QC procedures for data collection were carried out in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, ensuring both international comparability and consistency. To enhance accuracy and reliability, the sources of information were obtained from relevant government bodies and verified web-based sources. Data derived from the land use matrix was further validated through consultations with experts from the Forest Research Training Centre and the International Centre for Integrated Mountain Development (ICIMOD). To align with the IPCC guidelines, the land use change matrix was prepared using the IPCC land class values. During the data analysis process, several inconsistencies and inaccuracies were identified and addressed through discussions with officials from the Climate Change Management Division, leading to necessary adjustments. All datasets were securely stored, well-organized, and regularly backed up to prevent data loss. This report was prepared in accordance with the UNFCCC reporting principles, ensuring transparency, accuracy, clarity, completeness, and consistency.

3.9.10 Category-specific planned improvements

In the context of Nepal, several planned improvements can be undertaken to enhance emission estimates within the LULUCF sector, drawing on global best practices. Establishing a comprehensive data hub and sharing platform will improve access to activity data, emission factors (EFs), and research outputs, ensuring greater consistency and transparency. With increased ground-based research, Nepal can develop national-level emission factors, significantly enhancing the accuracy of its estimates. Conducting systematic reviews of research papers on carbon stocks, emission factors, and land-use dynamics will provide a robust scientific foundation for refining estimation methodologies. Nepal could also benefit from technical cooperation agreements or partnerships aimed at reducing uncertainties, acquiring high-quality data, and conducting targeted studies on previously estimated emissions, such as those from forest fires without land-use change and harvested wood products. Furthermore, reviewing and improving carbon stock data for native vegetation and better estimating emissions and removals from grasslands will ensure more comprehensive and accurate reporting. Expanding national studies and methodologies will help address existing gaps, improve classification systems, and strengthen Nepal's capacity to monitor and report on LULUCF-related emissions and removals more effectively.

3.10 Waste

The waste sector covers greenhouse gas (GHG) emissions occurring from solid waste disposal techniques, biological treatment/compost, incineration/open burning activities, and wastewater treatments (domestic and industrial).

3.10.1 Description of the waste sector in Nepal

Solid waste management has emerged as a critical concern, particularly in Nepal's urban areas. In many areas of Nepal, managing solid waste and wastewater treatment has been given a low priority due to the overwhelming demand for other public services. Due to poor management of waste, it results in serious environmental degradation and public health threats (Alam et al., 2007). Waste decomposition, incineration, open burning, and fugitive sources have grown to be a significant source of greenhouse gases (GHGs) and other harmful pollutant emissions (Das et al., 2018; Nagpure et al., 2015; Shrestha, 2018; Shrestha et al., 2013; TNC, 2017). A significant amount of CH_4 is also released from the decomposition of waste, which has a high Global Warming Potential (GWP) to the environment (Das et al., 2018; Shrestha, 2018). The fugitive emissions from the waste sector (including wastewater treatment) are poorly characterized and underestimated sources of air pollution in developing countries (IPCC, 2006). The majority of fugitive emissions are minor, do not have immediate consequences, and are challenging to find. Fugitive emissions include a number of poorly known routes for the most potent and long-lived GHGs and ozone depleting compounds into Earth's atmosphere (Laconde et al., 2018). In particular, fugitive emissions frequently escape into the atmosphere without proper containment or control measures, making them a challenging target for environmental management.

Previous studies of Nepal (Das et al., 2018; Gautam, 2006; INC, 2004; Shrestha, 2018; SNC, 2014; TNC, 2021) present GHGs emission from waste sector. Those studies also highlight the need for more variables to reduce uncertainty associated with the findings. In light of those studies and in order to uphold the Government of Nepal's international commitments made thus far (such as the Paris Agreement, the NDC, and the UN Sustainable Development Goals), this study aimed for developing a database of greenhouse gases (GHGs) released by different waste categories such as disposal of solid waste, the biological treatment of solid waste, open burning and incineration, and the treatment and discharge of wastewater. New Version 2.95 – IPCC Inventory Software is used for baseline assessment of GHGs from waste sector from the years 1994-2022, whereas Low Emissions Analysis Platform (LEAP) computational tools is used for scenarios development and GHGs projections up-to 2050 considering the base year 2022.

Table 34: IPCC emission categories in waste sector relating to Nepal

Category code	Category Name	Remarks
4	Waste	
4 A	Solid Waste Disposal	
4 A 1	Managed Waste Disposal Sites	Only limited practices
4 A 2	Unmanaged Waste Disposal Sites	Prevails mainly in urban areas
4 A 3	Uncategorized Waste Disposal Sites	Where disposal sites are not categorized properly
4 B	Biological Treatment of Solid Waste	Only limited practices and without information.
4 C	Incineration and Open Burning of Waste	

4 C 1	Waste Incineration	Mainly in health care facilities (but uncontrolled incineration)
4 C 2	Open Burning of Waste	Very common
4 D	Waste Water Treatment and Discharge	
4 D 1	Domestic Wastewater Treatment and Discharge	Only limited information is available
4 D 2	Industrial Wastewater Treatment and Discharge	Only limited information is available
4 E	Other	Not estimated

No- Not considered

The following categories of emissions were estimated by Nepal's Third National Communications (TNC) for 2011: solid waste disposal, biological treatment of solid waste, open burning of waste, and wastewater treatment and discharge (both domestic and industrial wastewater). The GHG inventory was estimated by the TNC using the 2006 IPPC Guidelines. However, INC (2004) and SNC (2014) excluded emissions from biological treatment of solid waste, incineration, and open burning of waste, while TNC (2021) excluded emissions from incineration practices.

3.10.2 Methodology

The IPCC (2006) National GHG Inventory Guidelines are used to estimate Nepal's waste sector's emissions. According to the 2006 Guidelines, Tier 1 Approach uses default emissions factors from the IPCC based on global averages for waste activities. The procedures and information needed in the various waste industry subcategories are compiled in Table 35. Tier 1 technique is used for the waste sector for developing Nepal's National GHGs Inventory.

The accompanying activity data is multiplied by emissions variables, correction factors, and the applicable emission factors to estimate the GHG emissions for each waste source category. Emissions can be broken down by individual pollutants (CO_2, CH_4, N_2O) or combined into total CO_2 equivalent emissions, depending on reporting requirements. In addition to the annual reports of the various ministries of the Government of Nepal, the Central Bureau of Statistics (CBS) and National Statistics Office (NSO) documents, as well as relevant research organizations and publications, provide the activity data for the different waste sources. Solid waste disposal, biological treatment of solid waste, incineration and open burning of garbage, and wastewater treatment and discharge are among the data collected that measure the degree of activity for each specified waste source category.

Table 35: Waste emission category and method used reported in Third National Communication of Nepal

Category	**Subcategory**	**Gases**	**Method**	**Required Data**	**Data sources and variables**
4A. Solid Waste Disposal	A1. Solid Waste Disposal	CH_4, N_2O	T1	Waste Generation Rate, Amount and Methods of Waste Disposal, Urban Population	ADB (2013), CBS (1995, 2003, 2012, 2021, 2023); Das et al. (2018); IPCC (2006); 2006SWMRMC (2004/2008); SWMTSC (2015); Pathak and Pokhrel (2023)
4B. Biological Treatment of Solid Waste	4B1. Biological Treatment of Solid Waste	CH_4, N_2O	T1	Fraction of Waste Composed	ADB (2013); IPCC (2006); TNC (2021)

4C. Incineration and Open Burning	4C2. Open Burning	CO_2, CH_4, N_2O	T1	Amount and type of waste burned	Amount and type of waste burned
4D. Wastewater Treatment & Discharge	4D1. Domestic Wastewater	CH_4, N_2O	T1	Population Data, Wastewater generated and treated per year, Protein consumption, Type of wastewater treatment system in use	CBS (1995, 2003, 2012, 2021, 2023); Data sheets; INC (1994); SNC (2000); TNC (2011); MoAD (1994-2022); KII; Webpage
	4D2. Industrial Wastewater	CH_4, N_2O	T1	Industrial Production Data	DoI (1994-2014); INC (1994); SNC (2000); TNC (2011); MoAD (1994-2022); Data sheets; KII; Webpage

The global warming potentials (GWPs) values from the IPCC AR5 (temporal horizon 100 years) were used to make it easier to report GHG values aggregate, expressed as carbon dioxide equivalents (CO2-eq) Annex I.I.

3.10.2.1 Solid waste disposal

The calculation of CH_4 emissions for dumping/disposal sites is based on the IPCC, 2006/2019. The country-specific waste disposal parameters/variables are not available nationwide; therefore, Tier 1 method is used. The annual CH_4 emissions from the disposal of solid waste are calculated using equation 1 (IPCC, 2006/2019). In an anaerobic setting, organic matter decomposes to produce CH_4. A portion of the generated CH_4 is either partially oxidized in the SWDS cover or recovered for energy or flaring. As a result, the amount of CH_4 emitted from the SWDS will be less than the amount generated.

$$CH_4\text{Emissions} = \left[\sum_x CH_4 \text{ gennerated} - R_T\right] * (1 - OX_T)$$

Where,

CH_4 Emissions = CH4 emitted in year T, Gg

T = inventory year

x = waste category or type/material

RT = recovered CH_4 in year T, Gg

OXT = oxidation factor in year T, (fraction)

Biological treatment of solid waste

The CH_4 emissions of biological treatment can be estimated using the default method from IPCC (2006/2009).

$$CH_4 \text{ Emissions} = \sum_i (M_i \times EF_i) \times 10_{-3} - R \quad (2)$$

Where,

Mi = mass of organic waste treated by biological treatment type i, Gg

EF = 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

The N_2O emissions of biological treatment can be estimated using the default method from IPCC (2006/2009).

$$N_2O\ Emissions = \sum_i (M_i \times EF_{-i}) \times 10_{-3} \quad (3)$$

N_2O Emissions = total N_2O emissions in inventory year, Gg N_2O

Mi = mass of organic waste treated by biological treatment type i, Gg

EF = emission factor for treatment i, g N_2O/kg waste treated

i = composting or anaerobic digestion

Incineration and open burning of waste

Both country-specific waste burning parameters/variables and IPCC default values are used to estimate the quantity of incineration and open burning of waste as well as emissions (IPCC, 2006/2019). The total amount of clinical waste incineration was estimated, referring to the recent study (MoHP, 2024), which was further applied for emission estimation. The total amount of municipal solid waste open-burned was estimated using the default method from II$U = \sqrt{(U1^2 + U2^2)}$

$$MSW_B = P * P_{frac} * MSW_P * B_{frac} * 365 * 10^{-6}$$

Where,

MSWB = Total amount of municipal solid waste open-burned, Gg/yr

P = population (capita)

Pfrac = fraction of population burning waste, (fraction)

MSWP = per capita waste generation, kg waste/capita/day

Bfrac = fraction of the waste amount that is burned relative to the total amount of waste treated, (fraction)

365 = number of days by year

10-6 = conversion factor from kilogram to gigagram

$$CO_2\ Emissions = MSW * \sum_j (WF_j * dm_j * CF_j * FCF_j * OF_j) * \frac{44}{12}$$

Where,

CO_2 Emissions = CO_2 emissions in inventory year, Gg/yr

MSW = total amount of municipal solid waste as wet weight incinerated or open-burned, Gg/yr

WFj = fraction of waste type/material of component j in the MSW (as wet weight incinerated or openburned)

dmj = dry matter content in the component j of the MSW incinerated or open-burned, (fraction)

CFj = fraction of carbon in the dry matter (i.e., carbon content) of component j

FCFj = fraction of fossil carbon in the total carbon component j

OFj = oxidation factor, (fraction)

44/12 = conversion factor from C to CO_2

with: ΣjWFj = 1

j = component of the MSW incinerated/open-burned such as paper/cardboard, textiles, food waste, wood, garden (yard) and park waste, disposable nappies, rubber and leather, plastics, metal, glass, other inert waste.

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

Where:

CH_4 Emissions = CH_4 emissions in inventory year, Gg/yr

IWi = amount of solid waste of type i incinerated or open-burned, Gg/yr

EFi = aggregate CH_4 emission factor, kg CH_4/Gg of waste

10-6 = conversion factor from kilogram to gigagram

i = category or type of waste incinerated/open-burned, specified as follows:

MSW: municipal solid waste, ISW: industrial solid waste, HW: hazardous waste,

CW: clinical waste, SS: sewage sludge, others (that must be specified)

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

Where,

N_2O Emissions = N_2O emissions in inventory year, Gg/yr

IWi = amount of incinerated/open-burned waste of type i , Gg/yr

EFi = N_2O emission factor (kg N_2O/Gg of waste) for waste of type i

10-6 = conversion from kilogram to gigagram

i = category or type of waste incinerated/open-burned, specified as follows:

MSW: municipal solid waste, ISW: industrial solid waste, HW: hazardous waste,

CW: clinical waste, SS: sewage sludge, others (to be specified)

Waste water treatment and discharge

Domestic wastewater treatment and discharge

CH_4 emissions from domestic wastewater

Estimating emissions from domestic wastewater treatment requires the application of equation 8 (IPCC, 2006/2019).

$$\mathbf{CH_4\ Emissions_j = \left[(TOW_j - S_j) * EF_j - R_j\right]}$$

Where,

CH_4 Emissionsj = CH_4 emissions from treatment/discharge pathway or system, j, in inventory year, kg CH_4/yr

TOWj = organics in wastewater of treatment/discharge pathway or system, j, in inventory year, kg BOD/yr.

Sj = organic component removed from wastewater (in the form of sludge) from treatment/discharge pathway or system, j, in inventory year, kg BOD/yr. For wastewater discharged to aquatic environments, there is no sludge removal (Sj = 0) and no CH_4 recovery (Rj = 0).

j = each treatment/discharge pathway or system

EFj = emission factor for treatment/discharge pathway or system, j, kg CH_4/kg BOD.

Rj = amount of CH_4 recovered or flared from treatment/discharge pathway or system, j, in inventory year, kg CH_4/yr. Default value is zero.

$$\mathbf{N_2O\ Plants_{DOM} = \left[\sum_{i,j} (U_i * T_{ij} * EF_j)\right] * TN_{DOM} * \frac{44}{28}}$$

Where,

N_2O Plants DOM = N_2O emissions from domestic wastewater treatment plants in inventory year, kg N_2O/yr

TNDOM = total nitrogen in domestic wastewater in inventory year, kg N/yr.

Ui = fraction of population in income group i in inventory year.

Tij = degree of utilisation of treatment/discharge pathway or system j, for each income group fraction i in the inventory year.

i = income group: rural, urban, high income and urban low income

j = each treatment/discharge pathway or system

EFj = emission factor for treatment/discharge pathway or system j, kg N_2O-N/kg N

The factor 44/28 is for the conversion of kg N_2O-N into kg N_2O.

Industrial wastewater treatment and discharge

CH_4 emissions from industrial wastewater

CH_4 emissions in the inventory year can be estimated using the default method from IPCC (2006/2019).

$$\mathbf{CH_4\ Emissions} = \sum_i \left[(\mathbf{TOW_i} - \mathbf{S_i}) * \mathbf{EF_i} - \mathbf{R_i} \right] * \mathbf{10^{-6}}$$

Where,

CH_4 Emissions = CH_4 emissions in inventory year, Gg CH_4/yr

TOWi = total organically degradable material in wastewater from industry i in inventory year, kg COD/yr

i = industrial sector

Si = organic component removed from wastewater (in the form of sludge) in the inventory year, kg COD/yr

EFi = emission factor for industry i, kg CH_4/kg COD for treatment/discharge pathway or system(s) used in inventory year

If more than one treatment practice is used in an industry, this factor would need to be a weighted average.

Ri = amount of CH_4 recovered or flared in inventory year, kg CH_4/yr

10-6 = conversion of kg to Gg

$$\mathbf{N_2O\ Plants_{IND}} = \left[\sum_i \left(\mathbf{T_{ij}} * \mathbf{EF_j} * \mathbf{TN_{INDi}} \right) \right] * \frac{\mathbf{44}}{\mathbf{28}}$$

Where,

N_2O PlantsIND = N_2O emissions from industrial wastewater treatment plants in the inventory year, kg N_2O/yr

TNINDi = total nitrogen in wastewater from industry i in inventory year, kg N/yr.

Tij = degree of utilization of treatment/discharge pathway or system j, for each industry i in the inventory year

i = industry

j = each treatment/discharge pathway or system

EFj = emission factor for treatment/discharge pathway or system j, kg N_2O-N/kg N.

The factor 44/28 is for the conversion of kg N_2O-N into kg N_2O

3.10.3 Activity data

3.10.3.1 Solid waste disposal site

To estimate emission from solid waste disposal site, data sets like population of urban areas (per capita), municipal waste generation rate (MSWGR) (kg/person/yr), total landfilled/MSW disposed at SWDS (Gg), waste disposed at SWDS (%), organic waste composition (%), paper (%), rubber/leather (%), wood (%), plastic (%), textile (%) were obtained from various literature, as depicted below.

The urban population of the years 1991, 2001, 2011, and 2021 was obtained from CBS 1995, CBS 2003, CBS 2012, and CBS 2022, respectively. The compound annual growth rates (CAGR) were estimated based on the data, which were further applied in linear regression models to get data on the urban population from 1994 to 2022. The MSWGR for urban areas of Nepal was available only for the years 2003 (SWMRMC, 2004), 2007 (SWMRMC, 2008), and 2012 (ADB, 2013). As national context data of MSWGR was not available after 2013, we considered the average per capita of 21 municipalities of Kathmandu Valley. MSWGR for 2014 (SWMTSC, 2015), 2016 (Das et al., 2018), and 2021 (Pathak & Pokhrel, 2023) were based on KV. Due to the unavailability of urban MSWGR from 1994-2002, we assumed the same value of 2003 (SWMRMC, 2004). The MSWGR for the year 2004-2006 was based on the average value between (2004) and SWMRMC (2008), while 2008-2011 (average value from SWMRMC, 2008 and ADB, 2013); 2013 (average value from ADB, 2013 and SWMTSC, 2015); 2015 (average value from SWMTSC, 2015 and Das et al., 2018); and 2017-2020 (average value from Das et al., 2018, and Pathak and Pokhrel, 2023). The year 2022 was assumed to have the same value as that of 2021 (Pathak & Pokhrel, 2023). The MSWGR and the quantity of waste generated are presented in the Annex X.II.

According to the ADB (2013), waste collection efficiency (WCE) or solid waste disposal for urban areas of Nepal is only reported for 2012. Due to the unavailability of the yearly-wise literature of this type for urban areas of Nepal, we have assumed the same value of ADB (2013) for the rest of the years. The value of organic waste for the years 2003, 2007, and 2012 for urban areas of Nepal was reported in the literature, SWMRMC (2004), SWMRMC (2008), and ADB (2013), respectively. SWMRMC (2004) and SWMRMC (2008) report waste composition for plastic, paper, metal, and glass in a single category. Considering this value and waste categorized data from ADB (2013), plastic and paper composition were estimated, while rubber/leather was assumed to be the same. From 1994 to 2002, the waste composition value for 2003 was considered. From the years 2004-2006, the average value was estimated, referring to SWMRMC (2004) and SWMRMC (2008). For the years 2008-2011, average values from SWMRMC (2008) and ADB (2013) were estimated. Due to the unavailability of waste composition data after 2012, the same value of ADB (2013) was considered. Waste disposal amount and composition of urban areas of Nepal are presented in the Annex X.III

3.10.3.2 Biological treatment of solid waste

While Nepal has a large number of small-scale anaerobic digestion biogas plants, they do not handle solid waste. For this inventory, it is assumed same percentage of composting (i.e, 5%) with that of TNC (2021). Based on it and total organic waste generation, amount of compost from 1994-2022 was estimated Annex X.IV.

3.10.3.3 Incineration and open burning of waste

Incineration

Nepal currently lacks suitable incinerators to handle solid garbage. Commonly, garbage is incinerated in built-in chambers. Therefore, this analysis considered uncontrolled waste incineration. Altogether 30 healthcare facilities (HCFs) (both specialized and teaching hospitals) have been considered for garbage incineration. The clinical waste burning of Tribhuvan University Teaching Hospital (TUTH) was estimated for the year 2022 referring to MoHP (2024), which was further converted to bed wise incineration from 1994-2022. The clinical waste burning for the remaining HCFs were calculated referring to bed wise incineration of TUTH and total number of beds of each HCF. The number of beds added in the respective years is also considered. The total amount of clinical waste incinerated is presented in the Annex X.V.

Open burning of waste

The data sets like urban population, rural population, urban waste generation rate, rural waste generation rate, and solid waste composition from 1994-2022 have been considered from various literature. The national and urban population of the years 1991, 2001, 2011, and 2021 were obtained from CBS 1995, CBS 2003, CBS 2012, and CBS 2022 respectively. The CAGR was estimated based on those data, which were further applied in linear regression model to get data of national and urban population from 1994-2022. The rural population was estimated by subtracting urban population from national population. The value of urban MSWGR was considered from section SWDS. The MSWGR for semi-rural areas is available only for 2016

(SWMTSC, 2017). Therefore, we assumed it same for the rest of the years (1994-2022). After multiplying urban and rural waste generation rate with its population, total quantity of waste was estimated for Nepal. The composition wise waste quantity from 1994-2022 was obtained similar to section SWDS. The open waste burning parameters (Pfrac and Bfrac) were considered for Nepalese context (Das et al., 2018) to estimate composition wise mass of MSW open burnt Annex X.VII.

3.10.3.4 Waste water treatment

Domestic wastewater treatment

In Nepal, there aren't many domestic wastewater treatment facilities, and the majority of wastewater is untreated. This study compiled 12 wastewater treatment facilities, based on the availability of data sets and functioning status. The untreated and treated waste were further categorized. Total populations served in domestic water treatment was collected from the available literature, key informant interview and on-site visit, while national urban population from 1994-2022. The urban population for wastewater discharge or untreated was estimated considering total urban population and population of domestic wastewater treatments. The value of sludge removed (kg BOD), flaring (kg CH_4), and energy use (kg CH_4 Nitrogen in wastewater was not considered dvue to unavailability of data. Per capita protein consumption was obtained from MoAD (1994-2022). Rivers and constructed wetlands (horizontal sub-surface flow) are the types of domestic WWT plants. While various parameters like emission factors (kg CH_4/kg BOD; N_2O/person/year; kg N_2O-N/kg N; kg N_2O/year), degradable organic component (g/cap/day), correction factor for BOD discharged in sewers, degree of utilization of WWT plants, methane production capacity, methane correction factor, fraction of nitrogen in protein, fraction of non-consumption protein, and fraction of industrial co-discharged protein were considered from IPCC (2006), as default values.

Industrial wastewater treatment

Only limited data exists for industrial waste treatment plants (IWWTP). The activity data of industrial production was collected from available literature (DoI, 1994-2014; INC, 1994; SNC, 2000; TNC, 2011; MoAD, 1994-2022). The waste category includes alcohol refining, beer & meat, dairy products, meat & poultry, organic chemicals, plastics & resins, pulp & paper, soap & detergent, starch production, and vegetables, fruit & juice, all in units of tonnes. Most of the data is available from 2001-2014, except for dairy and meat products. The untreated industrial wastewater or discharge from 2001-2014 was estimated referring to total industrial production and treated waste, while remaining years data was estimated based on linear regression model and annual growth rate depending upon the data structure. In this study, four IWWTPs have been taken into account for waste treatment considering its functionality, availability of data, KII and onsite visit. The daily flow rate of industrial wastewater by type (m3/day) was further calculated referring to IPCC (2006) and industrial productions by type. While various parameters like emission factors (kg CH_4/kg COD; kg N_2O-N/kg N), wastewater generated (m3/t), chemical oxygen demand (kg COD/m3), methane production capacity (kg CH_4/kg COD), methane correction factor (Frac), and total N concentration in industrial wastewater treated by constructed wetlands were considered from IPCC (2006), as default values. The quantity of treated industrial waste and untreated discharge is reflected in the Annex X.X

3.10.4 Emission Factors

The default value of emission factors (EFs) for biological treatment of solid waste, waste water treatment, and MSW open burning/incineration have been considered from IPCC (1996/2006) as presented in Annex X.XI.

3.10.5 Trend of GHG emissions by categories

The emissions from the waste sector between 1994 and 2022 show an upward trend. In the year 1994, the highest emissions were from wastewater treatment, followed by emissions from solid waste disposal, then emissions from open burning and biological treatment. The growing amount of solid waste being disposed of in Nepal is the cause of the rise in emissions from solid waste. According to Nepal's new constitution, 252 municipalities were added after 2015.

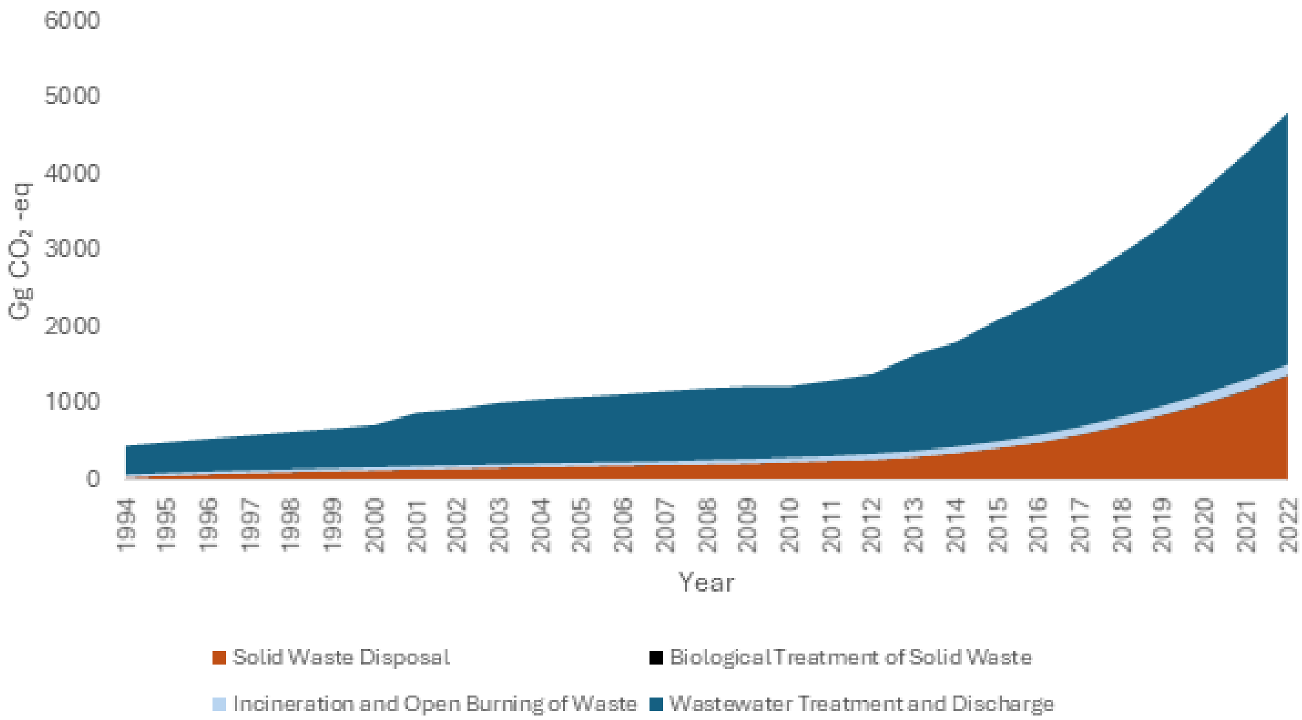


Figure 48: GHG emission trend by categories of waste sector from 1994-2022

3.10.6 Recalculation of emissions 1994-2011 for the waste sector

This study considers solid waste disposal based on waste collection efficiency, while INC and SNC have not reported the sources. Though TNC assumes waste collection efficiency similar to this study; however, the values are different. The choices of methods of this study (IPCC, 2006) using advanced software (version 2.93) with more variables compared to IPCC (1996) also have a profound impact on the findings. Likewise, INC and SNC have not accounted for open burning and biological treatment of waste, hence the values are not compared with recalculated values, while it is compared with TNC. Also, the open burning of waste for the year 2011 for TNC is just assumed (i.e., 10%), while the recalculated value is based on the activity data collected from various literature and estimations. Also, waste incineration is not covered in any communication reports. This is the reason for the significant difference between the recalculated value and TNC. The data before 1994 on wastewater treatment plants are not available officially. Therefore, we have excluded them in the recalculations, which could have caused a significant difference. The recalculation of emissions from the waste sector is presented in Figure 49.

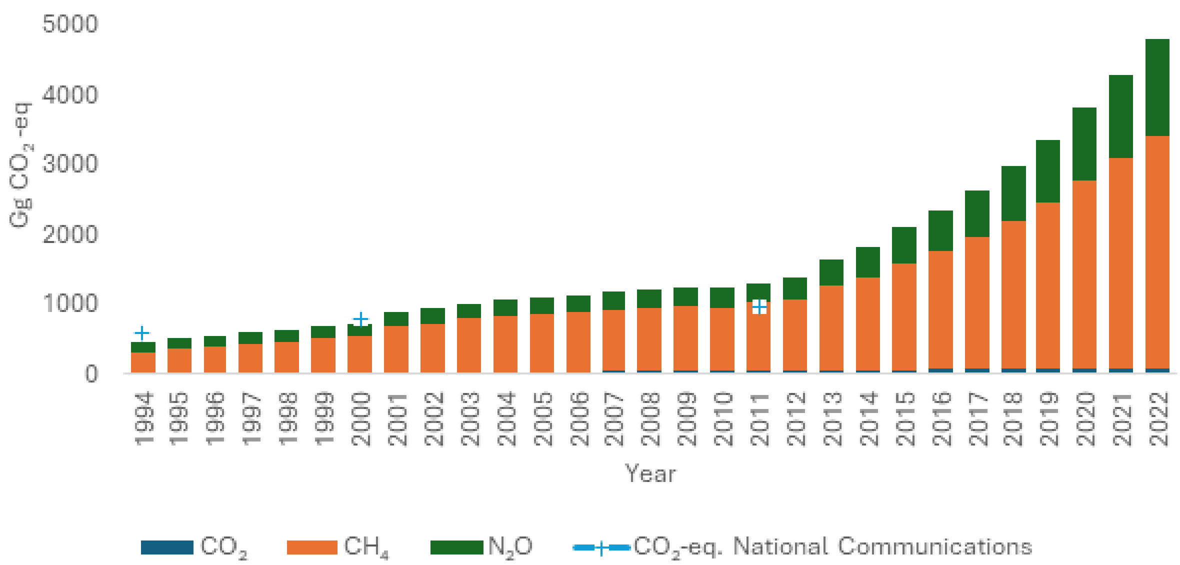


Figure 49: GHG emissions from the waste sector during 1994-2011

Table 36: Recalculation of INC GHG emissions in 1994

Categories			Emissions [Gg]				
	Revised CO_2	INC CO_2	Revised CH_4	INC CH_4	Revised N_2O	INC N_2O	Remarks
4.A - Solid Waste Disposal			1.10	9.33	0.0		This study considers Sisdole landfill site, which operated from 2005.
4.B - Biological Treatment of Solid Waste			0.03	N/A	0.001	N/A	
4.C - Incineration and Open Burning of Waste	16.3	N/A	0.51	N/A	0.006	N/A	
4.D - Wastewater Treatment and Discharge			9.04	1.14	0.48	1.10	

Table 37: Recalculation of SNC GHG emissions in 2000

Categories			Emissions [Gg]				
	Revised CO_2	INC CO_2	Revised CH_4	INC CH_4	Revised N_2O	INC N_2O	Remarks
4.A - Solid Waste Disposal			4.48	12.16			
4.B - Biological Treatment of Solid Waste			0.04	N/A	0.002	N/A	
4.C - Incineration and Open Burning of Waste	19.01	N/A	0.60	N/A	0.008	N/A	
4.D - Wastewater Treatment and Discharge			13.12	4.58	0.70	1.19	

Table 38: Recalculation of TNC GHG emissions in 2011

Categories			Emissions [Gg]				
	Revised CO_2	INC CO_2	Revised CH_4	INC CH_4	Revised N_2O	INC N_2O	Remarks
4.A - Solid Waste Disposal			8.83	10.46			
4.B - Biological Treatment of Solid Waste			0.06	0.10	0.003	0.01	
4.C - Incineration and Open Burning of Waste	35.63	2.36	0.80	0.34	0.01	0.01	
4.D - Wastewater Treatment and Discharge			25.34	11.45	1.06	1.20	

3.10.7 GHG Emissions Inventory of 2012-2022 for the waste sector

The GHG emissions from 2012 to 2022 are shown in Figure 50. In recent years, significant rises in disposal sites have resulted in CH_4 accounting for the majority of GHG emissions (91.7%), followed by CO_2 (4.3%), and N_2O (4%).

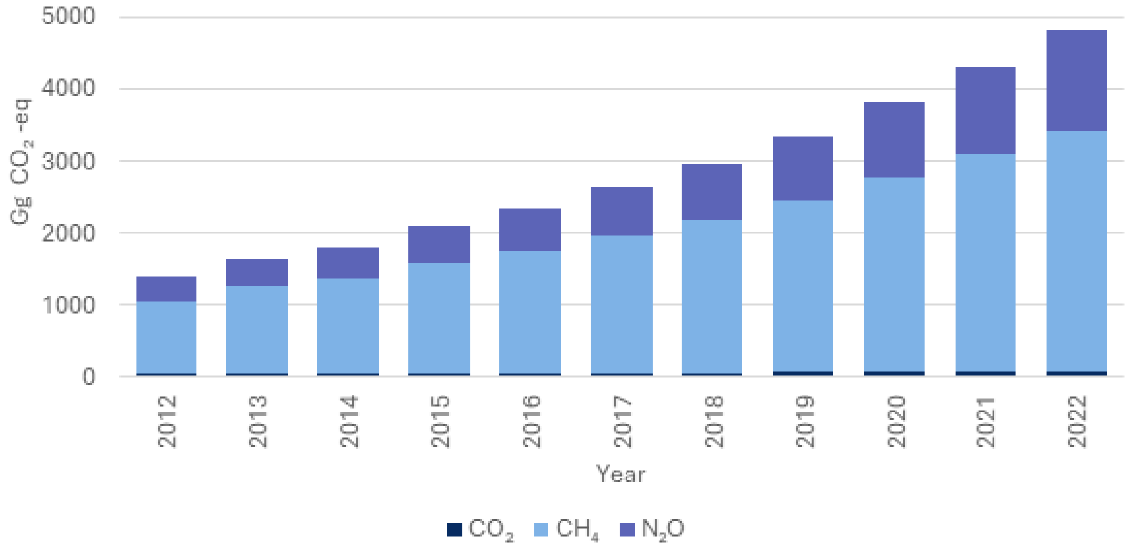


Figure 50: GHG emissions from the waste sector from 2012 – 2022

Table 39: Emission from the waste sector in 2022

Categories	Net CO_2 emissions / removals			
	CO_2	CH_4	N_2O	Total
	Gg	Gg CO_2-eq	Gg CO_2-eq	Gg CO_2-eq
4 - Waste	**79.623**	**3340.697**	**1393.971**	**4814.291**
4.A - Solid Waste Disposal		1363.106		1363.106
4.A.1 - Managed Waste Disposal Sites		1.491		1.491
4.A.2 - Unmanaged Waste Disposal Sites		858.945		858.945
4.A.3 - Uncategorized Waste Disposal Sites		502.671		502.671
4.B - Biological Treatment of Solid Waste		8.964	4.878	13.843
Composting		8.964	4.878	13.842
Anaerobic digestion at biogas facilities				0
Other				0
4.C - Incineration and Open Burning of Waste	79.623	44.519	6.248	130.390
4.C.1 - Waste Incineration	0.566	0.002	0.015	0.583
4.C.2 - Open Burning of Waste	79.057	44.517	6.233	129.807
4.D - Wastewater Treatment and Discharge		1924.107	1382.845	3306.952
4.D.1 - Domestic Wastewater Treatment and Discharge		572.440	1382.844	1955.284
4.D.2 - Industrial Wastewater Treatment and Discharge		1351.667	0.001	1351.668
4.E - Other (please specify)	0	0	0	0

3.10.8 Uncertainty assessment and time series consistency

Table 40: Uncertainty in GHG Emissions of Waste Sector

2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO_2)	Year T emissions or removals (Gg CO_2)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)
4 - Waste						
4.A - Solid Waste Disposal	CH_4	262.96	1363.11	173.21	0.00	173.21
4.B - Biological Treatment of Solid Waste	CH_4	1.90	8.96	100.00	100.00	141.42
4.B - Biological Treatment of Solid Waste	N_2O	1.03	4.88	100.00	150.00	180.28
4.C - Incineration and Open Burning of Waste	CO_2	44.70	79.62	70.71	56.57	90.55
4.C - Incineration and Open Burning of Waste	CH_4	24.90	44.52	70.71	141.42	158.11
4.C - Incineration and Open Burning of Waste	N_2O	3.50	6.25	70.71	141.42	158.11
4.D - Wastewater Treatment and Discharge	CH_4	723.57	1924.11	147.65	60.00	159.37
4.D - Wastewater Treatment and Discharge	N_2O	324.48	1382.84	40.00	60.00	72.11
4.E - Other (please specify)	CO_2	0.00	0.00	0.00	0.00	0.00
4.E - Other (please specify)	CH_4	0.00	0.00	0.00	0.00	0.00
4.E - Other (please specify)	N_2O	0.00	0.00	0.00	0	0.00

3.10.9 Category-specific QA/QC and verifications

Tier 1 QA/QC procedures are implemented for the Category 4 Waste Sector. The QA/QC procedures followed the general principles and QA/QC plan guidelines. The verification process included the following for the waste sector, as recommended by the IPCC guidelines (IPCC, 2006).

1. Reviewing activity data for accuracy: Ensuring proper data entry and completeness.
2. Verifying emission factors: Ensuring they are up-to-date and relevant for the region.
3. Cross-checking data consistency: Ensuring calculations are consistent across time series.
4. Identifying and correcting discrepancies: Addressing gaps or inconsistencies in data and maintaining consistency in activity data and emission factors, applying necessary conversion factors when needed. Data and factors should align with similar system boundaries (IPCC, 2006).

Quality Assurance/Quality Control procedures are conducted as an element of good practice to improve the quality of national inventories at all stages of GHG inventory preparation. Quality control is followed by Tier 1 general procedures and is carried out by experts from the technical group responsible for GHG inventory preparation. Various ministries, agencies, organizations, and public-private companies, categorized by emission sources, contributed to the quality assessment of the national GHG inventory, even though they are not directly involved in its preparation. Quality control procedures were implemented at every stage of the GHG inventory preparation process. Any changes or corrections were recorded in the corresponding quality control table. The following quality control activities are performed:

- Checking received activity data for mechanical errors.
- Verifying the accuracy of entered data to identify mechanical errors.
- Validating calculations to address activity data gaps using mathematical methods.
- Ensuring proper entry of emission units, parameters, and conversion factors.
- Reviewing greenhouse gas emission calculations for accuracy.
- Confirming the consistency of input data and calculations across time series, particularly when methods, emission factors, or other parameters changed.
- Ensuring formulas and calculations were correctly entered in modified worksheets according to national conditions.
- Validating calculations is involved in the development of national factors.
- Reviewing emission source documentation, including assumptions, criteria for selecting calculation methods, activity data, emission factors, and other multipliers.
- Verifying all references related to data and factors.
- Conducting cross-checks of the data for consistency and accuracy (UNFCCC, 2024, Uzbekistan: National Inventory Report).

3.10.10 Category-specific planned improvements

Table 41: Challenges, Limitations, and Necessity for the Waste Sector

Category	Challenges/Limitations	Necessity
Updated Data and Data Availability	- Lack of consistent and historical data on waste generation, composition, and management. -There is no centralized database for systematic updates. -Insufficient data on wastewater treatment plants, including their emissions and operational efficiency.	Accurate and updated data is essential for estimating GHG emissions and tracking trends in waste management practices.
Research to Establish National Emission Factors	-Limited studies on waste-specific emission factors for Nepal. -Lack of validation for existing data.	National emission factors reflect local waste characteristics, improving accuracy in GHG inventories.
Subsector-Level Studies	-Detailed studies on emissions from specific waste streams (e.g., solid waste disposal, wastewater treatment) require resources and expertise.	Subsector-level studies provide a bottom-up approach, capturing variations in emissions and improving inventory accuracy.

Inter-Agency Collaboration	- Poor coordination among agencies managing waste data. - No standardized reporting framework or shared platform for data exchange.	Collaboration ensures consistent and high-quality data collection and sharing for GHG inventory preparation.
Capacity Building and Training	- Limited awareness of IPCC guidelines for waste sector reporting. - Shortage of trained personnel for accurate data collection and analysis.	Skilled professionals are essential for implementing standardized methodologies and enhancing the quality of GHG inventories.

Table 42: Recommendations and Agencies

Category	Actions	Agencies
Data Collection and Availability	-Create a centralized database to track wastegeneration and management. -Set clear reporting guidelines for municipalities and private waste handlers. -Ensure regular updates from all stakeholders.	MoFE, SWMTSC, Municipalities
Data Disaggregation Suitable for IPCC Guidelines	-Separate data by waste type (organic, plastic, etc.) and treatment method.	MoFE, SWMTSC, Municipalities
Research to Establish National Emission Factors	-Analyze the impact of treatment technologies on emissions. -Study waste composition and emissions under local conditions and update findings regularly.	NAST, Universities, SWMTSC
Subsector Studies	- Assign specific agencies to study emissions from solid waste, wastewater, and biogas. - Use findings to improve national GHG inventories.	MoFE, SWMTSC, Municipalities
Collaboration	- Share data through a unified platform. -Conduct joint research to reduce emissions.	MoFE, SWMTSC, Municipalities
Training and Capacity Building	-Provide training in international waste reporting guidelines. -Work with global experts for technical and financial support. -Train teams to implement and monitor waste technologies.	MoFE, SWMTSC, Donor Agencies

3.11 Scenario Analysis and projection till 2050

3.11.1 GHG emissions projection till 2050

This chapter gives the emission projection till the year 2050. For this purpose, a model with an accounting framework has been developed. The methodology follows a mixed model of trend and scenario-based analysis. While trend analysis primarily relies on historical data for activity and emissions, scenario analysis incorporates historical and current trends and the influence of external parameters that can govern activities. For example, economic and population growth rates are considered key drivers in the energy sector, influencing GHG emissions based on changes in these drivers. Additionally, forestry targets aimed at increasing forest areas affect FOLU emissions and removals, while strategies to introduce high-productivity cattle impact livestock emissions, and so on.

For emission projection, scenario analysis was conducted using LEAP (Low Emissions Analysis Platform) software, developed by the Stockholm Environment Institute. LEAP can integrate both energy and non-energy sectors within a single toolkit (Heaps, 2024). The framework for emission projection through scenario analysis using LEAP is illustrated in Figure 51.

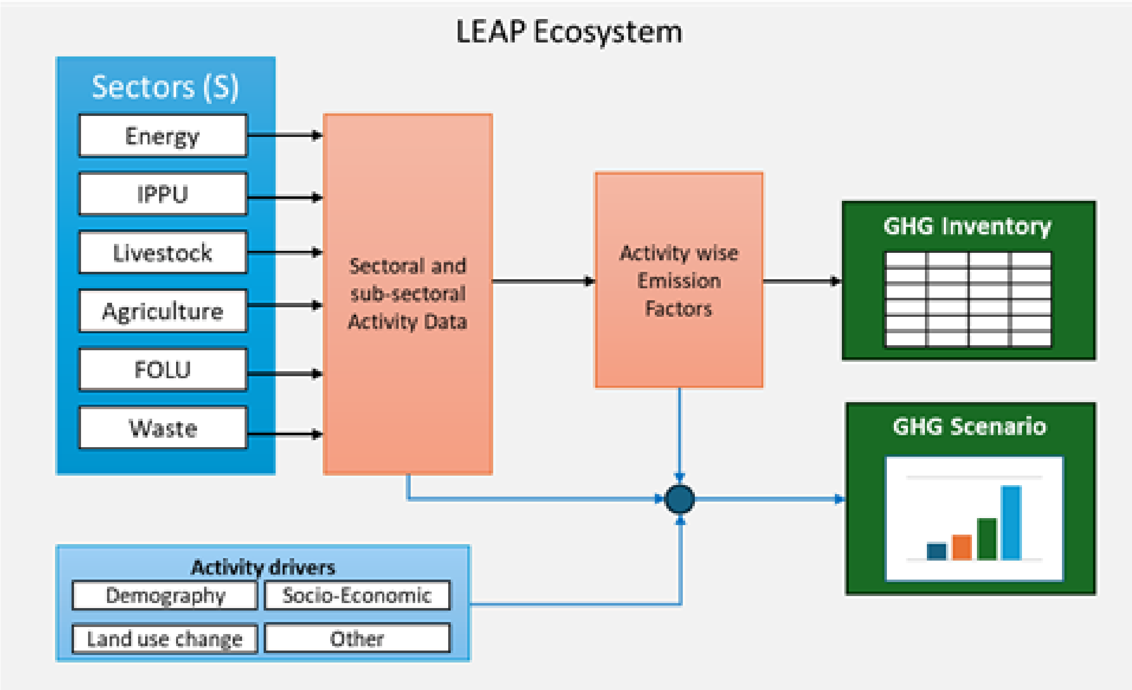


Figure 51: Framework for emission scenario model in LEAP for GHG trend analysis till 2050

3.11.2 Socio-economic assumption

Energy Sector

The process of developing scenarios depends on certain factors that drive the activities. Specific variables influence the rate at which these activities occur. In this study, activities are connected to economic and demographic factors. Agricultural, commercial, and industrial activities are assumed to depend on the gross value added (GVA) in each sector. For the residential sector, it is assumed to depend on the population and rate of urbanization. Meanwhile, the transport sector is influenced by both economic and demographic factors for freight and passenger transportation. These assumptions are based on those taken in the Long-term Strategies of Nepal (MoFE, 2021) and provincial energy reports (WECS, 2024, 2022, 2021). A general assumption in projecting the energy in each sector is that the energy intensity remains constant.

GDP growth rates are taken from the government document of the 16th periodic plan (NPC, 2024) and Long Term Strategies of Nepal. The population growth rate comes from census data (CBS, 2022) and the urban population growth rate is taken from NSO (2024). A key assumption in the model is that economic activities will follow GDP growth to meet the set targets, meaning that a growing sectoral GDP or GVA will require more activity, like increased production in that sector.

IPPU

Like the energy sector, industrial production is assumed to depend upon the national GDP and the manufacturing GVA; therefore, the driving factors in IPPU sectors are considered respectively. The driving factor for the cement production has been correlated with GDP, as per a report by the Department of Industries (MaDRA/DoI, 2019). Thus, the national GDP has been considered a driving factor for cement production. Meanwhile, the manufacturing GDP has been taken as the driving factor for the rest of the productive sectors.

Agriculture and Livestock

In the livestock and agricultural sectors, the activity data is not found to be directly correlated with economic outputs. Therefore, the trend of their growth based on the historical activity data has been estimated. The calculated growth rates have been used for livestock population, which are positive for some livestock while negative for others. The population data and the growth rates are given in the Annex VII.IX. Similarly, for the agricultural sector, it is assumed that rice harvested will be expanded by 2% (ref year 2022) by 2050 with the promotion of spring rice cultivation supported by extended irrigation facilities. Lime application is also expected to increase by 20% to address soil acidification caused by the extensive use of chemical fertilizers in the future. While the uses of urea and DAP (chemical fertilizers) are assumed to increase by 15% and 20% respectively by 2050, due to the increased capacity of the government to import or produce fertilizers as demanded by farmers. Further, the direct and indirect N_2O emissions from managed soils and indirect N_2O emissions from manure management will largely depend on the growth rates of respective livestock species, as used for projecting enteric fermentation and direct emissions from manure management.

Waste

The activity data is primarily driven by economic activity the demography, population, and urbanization. The waste production related to residential sectors is correlated with population and urbanization, which also indicates the increase in access to the waste management system. Whereas for industrial waste, the production of waste has been correlated to manufacturing GVA, like in prior subsectors.

LULUCF and Forest Fire

The cases for land use, land use change, and forestry are a bit different than other sub-sectors. There is no specific growth rate for land use change, and forest fires are random events. Therefore, in the case of land use and land use change, the forest fire linear historical trend has been forecasted till 2050. The projection of land use change indicates that forest land will continue to increase, eventually accounting for approximately 50% of the total area. In contrast, Cropland is expected to decrease by around 5% compared to 2022 levels. Other land use categories are projected to remain largely unchanged.

Table 43 shows the assumed driving factors taken for scenario development of each of the sectors.

Table 43: Sectoral Dependent Variables

Category	Sub-Sector/Activities	Driving Factors
Energy	Residential	Population and Urbanization
	Transport	National GDP and population
	Industrial	Industrial / Secondary sector GVA
	Commercial	Service sector GVA
	Agricultural	Agricultural/ Primary sector GVA
IPPU	Cement	National GDP
	Other products	Industrial / Secondary sector GVA
Agriculture	Livestock	Livestock population

	Agriculture – rice cultivation, liming, fertilizer use, and animal manure applied to soils	Expansion of rice harvested area; increased application of lime; increased use of urea and DAP, increased manure production and application to soils
Waste	Domestic waste generation	Population and Urbanization
	Industrial waste generation	Industrial / Secondary sector GVA
LULUCF	Land use area	Historical Trend

3.11.3 GHG emissions projections till 2050

3.11.4 Total GHG Emissions

The total GHG emissions, excluding LULUCF, are expected to grow at a rate of 3.3% starting from 2022, reaching 145,436 Gg CO_2-eq by 2050. When LULUCF is included, emissions in 2050 are expected to be 125,454 Gg CO_2-eq, mainly due to the high sequestration capacity of forest land. The emissions from the IPPU sector are growing the fastest, while emissions from livestock are growing the slowest. This suggests that industrialization is likely to have a greater impact on total emissions, while a shift away from agriculture may lead to lower emissions in that sector. However, it is important to analyze the social costs and benefits of each sector to ensure that the proper mitigation actions are taken without negatively affecting the country's economic output and well-being.

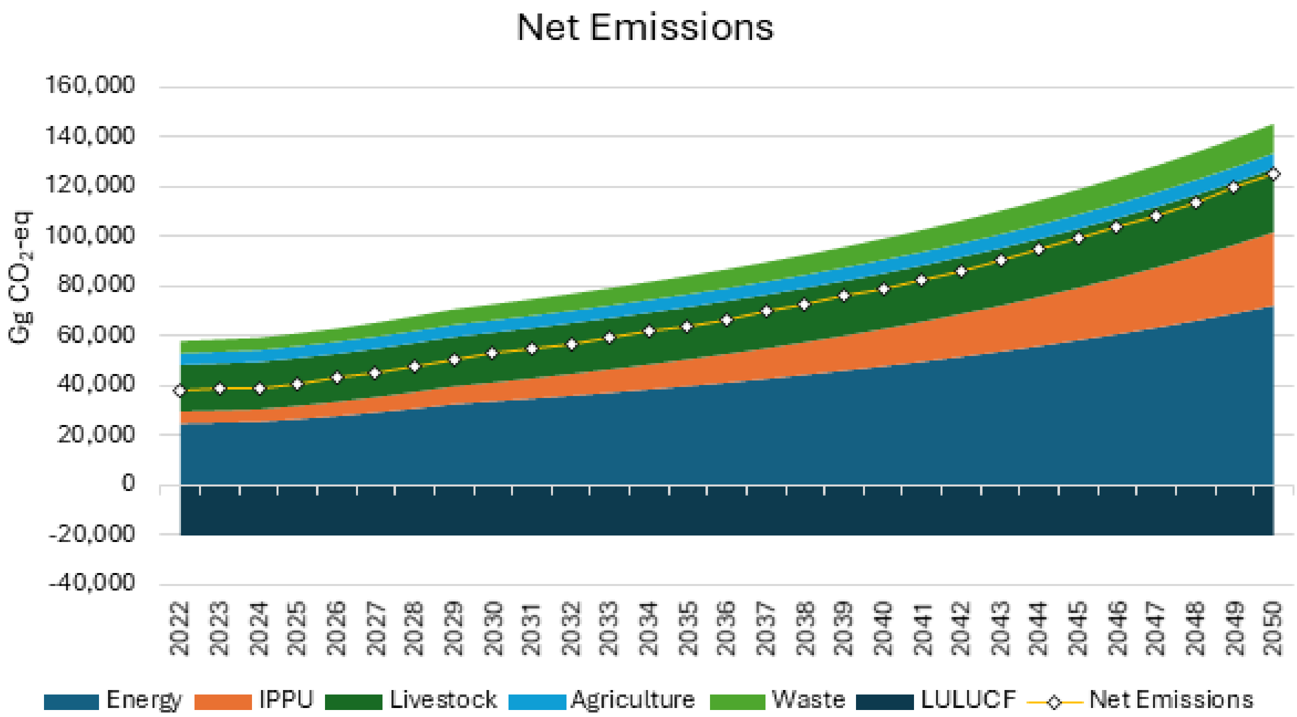


Figure 52 GHG emissions projection till 2050

Due to the different growth rates of each sector, the energy sector is expected to be the largest emitter by 2050, accounting for 50% of total national emissions (excluding LULUCF) (Figure 53). It will be followed by emissions from IPPU at 20% and from livestock at 18%. These results suggest that emission control strategies should prioritize the energy sector, as they can be more easily addressed through clean energy interventions. Emissions from other sectors are generally harder to reduce, but with the right strategies, they can either be reduced or managed through appropriate adaptation measures to minimize their impact.

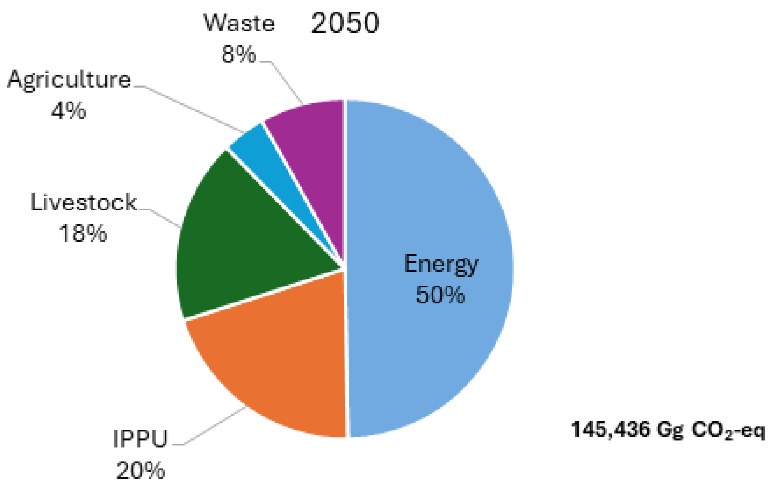


Figure 53: Shares of sectoral emissions in 2050 (excluding LULUCF)

In terms of GHG types, while methane emissions remain constant, CO_2 emissions are rising rapidly Figure 54. This indicates the cumulative impact of various factors, with the main factor being the change in emission sources. The slower growth in AFOLU activities, in contrast to the higher growth in fuel combustion, is the primary reason for this rise in CO_2 emissions. As fuel combustion increases, it leads to a significant increase in CO_2 emissions, while the relatively stable emissions from AFOLU activities, such as agriculture and land-use, contribute less to the overall increase.

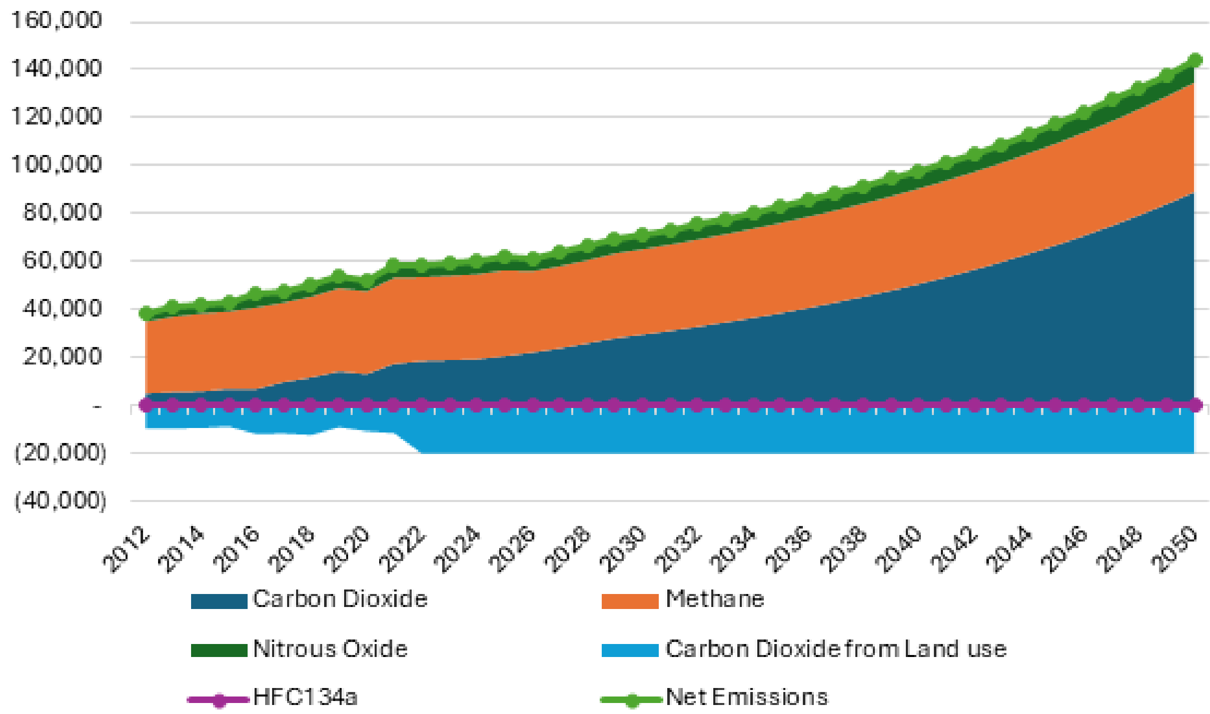


Figure 54: GHG emissions by gas type till 2050

3.11.5 Sectoral GHG emissions projection

Energy Sector

In the energy sector, GHG emissions are predicted to rise by an average of 3.9% each year from 2022 to 2050 (Figure 49). The growth will be faster in the first five years, driven by higher economic activity between 2024 and 2029, which will increase energy consumption. The industrial sector will see the highest growth in emissions, at about 6.7%, followed by the commercial and service sectors. The industrial sector is expected to grow at higher levels with increasing development activities, mainly related to hydropower and road construction. The increased manufacturing activity also aids the commercial and service sectors, and hence their energy consumption and associated emissions. This suggests that efforts to reduce GHG emissions should focus on these sectors. In contrast, emissions from the residential sector will be lower, due to people moving to urban areas and using cleaner fuels. This emphasizes the need for clean fuel solutions in the industrial and commercial sectors. To reduce emissions, strategies like switching to mass transportation and electrification are suitable for Nepal. Over the past decade, emissions have increased rapidly, mainly due to growth in industrial and transportation activities. Therefore, mitigation efforts should concentrate on these sectors while ensuring that economic development is not hindered.

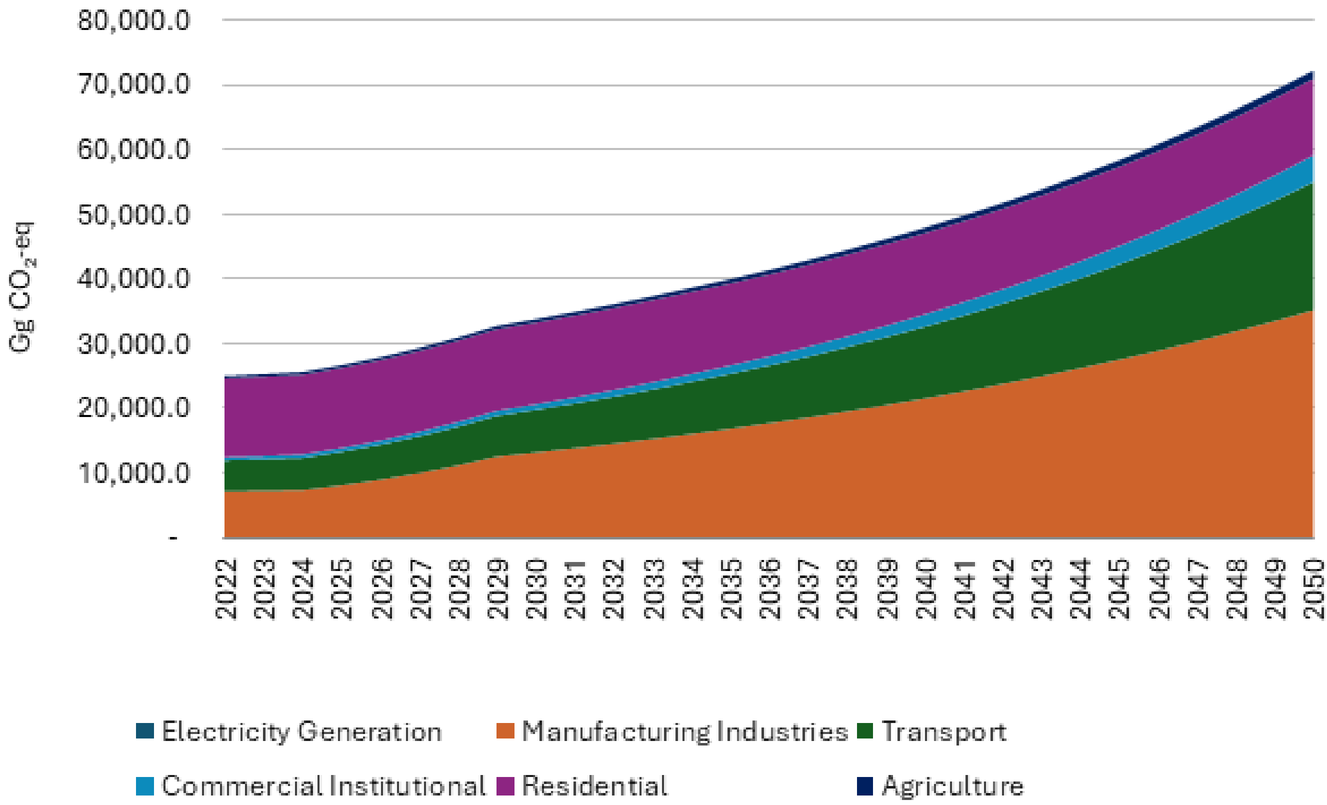


Figure 55: GHG emissions projection from the energy sector

IPPU Sector

Emissions from the IPPU sector grow significantly from 4811.59 Gg CO_2-eq in 2022 to 29,603.80 Gg CO_2-e in 2050. This sharp increase is driven primarily by the cement sector, which contributes over 99% of the emissions throughout the years. In 2022, cement emissions were 4792.239 Gg, and they are expected to rise steadily, reaching a substantial 29,574.02 Gg by 2050. This consistent growth reflects increasing industrial activity and demand for cement, likely driven by infrastructure and construction needs. Lubricant emissions, while much smaller, also show a gradual increase, starting at 1.90 Gg in 2022 and rising to 9.37 Gg by 2050. This growth suggests a steady expansion in industries reliant on lubricants, such as machinery and transportation. Similarly, paraffin emissions, the smallest contributor, grow from 0.75 Gg in 2022 to 3.71 Gg by 2050, indicating limited but consistent use in relevant applications. The upward trend across all activities highlights the importance of addressing emissions in this sector. Reducing emissions from cement production will be critical. Strategies could include using alternative materials, improving energy efficiency, and adopting carbon capture technologies.

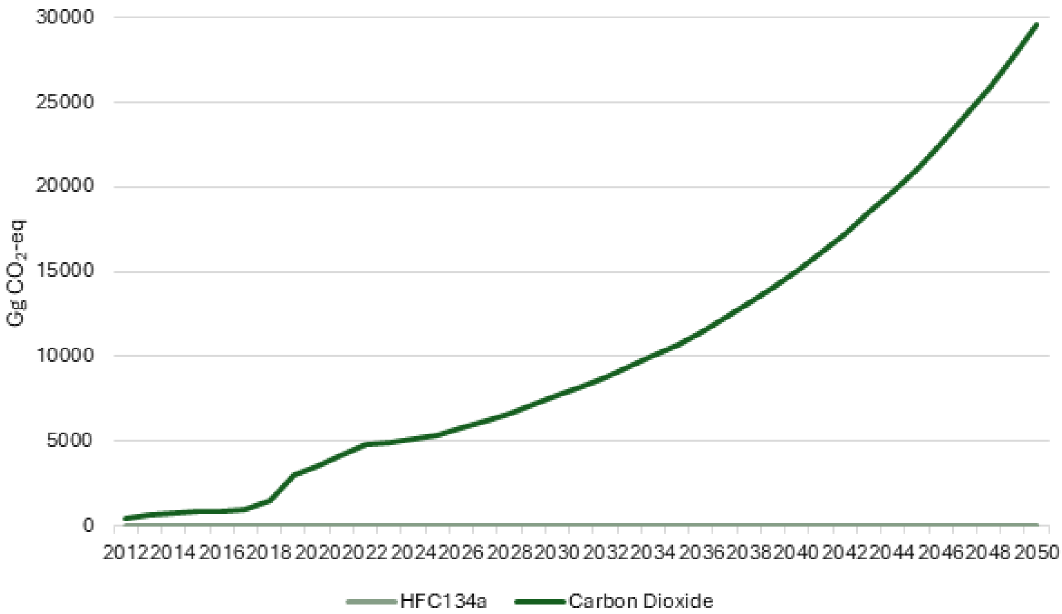


Figure 56: GHG emissions projection from IPPU sector

Agricultural and Livestock

Agriculture

In the agriculture sector, the total GHG emission is expected to increase by around 1.06% every year from 2022 to 2050; the emission in 2050 will be 30% higher compared to the 2022 emission (4690.65 Gg CO_2-eq). Methane emission from rice cultivation will rise at a rate of 0.072% per year, while the emission from direct N_2O emission from organic manure, urine and dung deposition and synthetic fertilizer application is expected to rise at the rate of 1.86% each year until 2050. The right rate of emission (2.77% per year) is expected for indirect N_2O emission from managed soils after 2022, while the indirect N_2O emission from manure management will rise at a rate of 0.74% per year until 2050.

For an increased use of urea by 20% by 2050, the CO_2 emission will rise at the rate of 0.58% with slightly higher growth rate in the starting years after 2022. For an increase by 20% in lime application compared to 2022, the CO_2 emission from liming will increase from 0.78% over years till 2050. Figure 57 shows the category wise projection of emissions until 2050 in the agricultural sector.

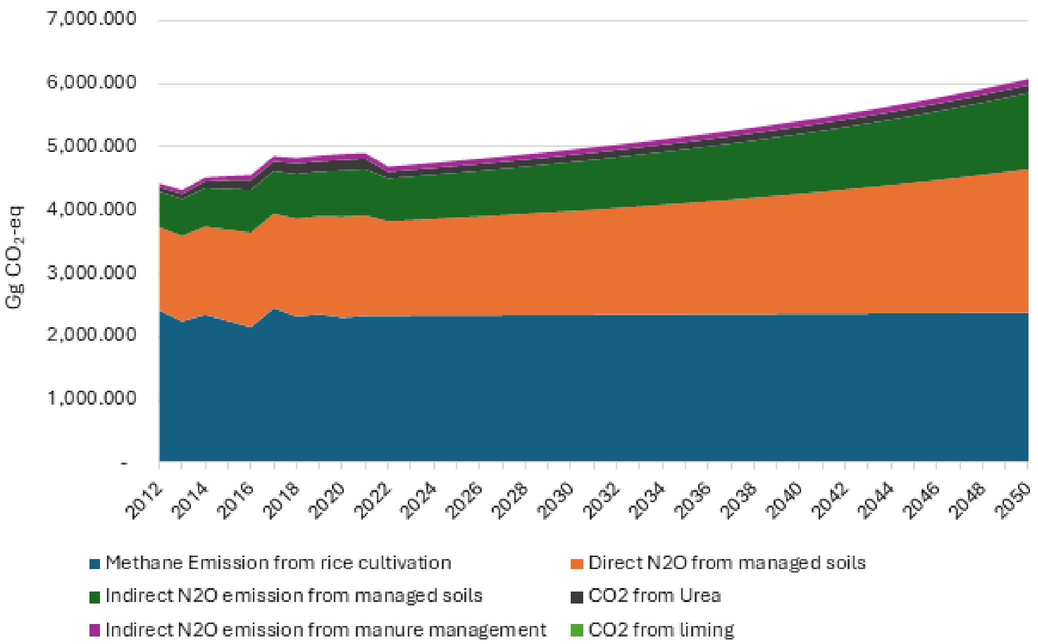


Figure 57: GHG emissions projection from agriculture

Livestock

The emission for the livestock sector tends to increase from 2022 to 2050, from 18723.50 Gg in 2022 CO_2 eq to 25,579.54 in 2050, which accounts for the rise of 36.62 % as presented in Figure 52. Methane emission is expected to increase from 18,199.97 Gg CO_2-eq in 2022 to 24,086.96 Gg CO_2-eq in 2050, which accounts for a 32.35% rise in methane emission in 2050. Similarly, the nitrous oxide also tends to increase from 523.53 Gg CO_2 -eq in 2022 to 1492.58 Gg CO_2-eq in 2050 which is 185.09% rise as presented in Figure 58.

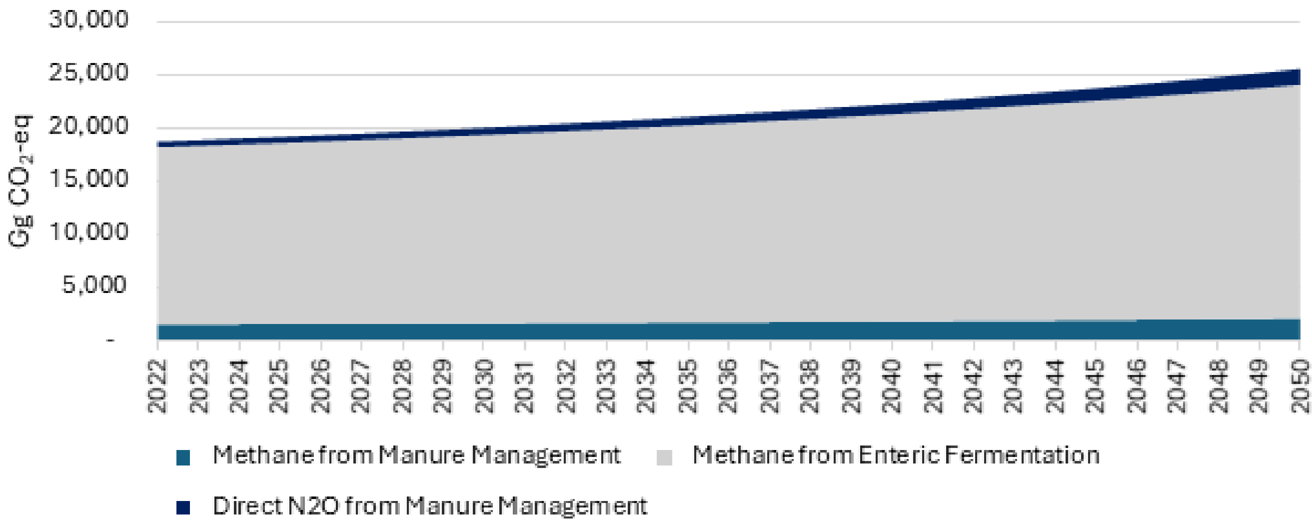


Figure 58: GHG emissions projection from livestock

LULUCF

The LULUCF emissions data from 2022 to 2050 shows consistent trends across categories, indicating that overall, the land use sector will remain a sink, due to the high area covered by forest. The total sink capacity will remain fairly constant at around 20,000 Gg CO_2-eq. Cropland emissions remain stable at around 6.3–6.4 thousand Gg, while Grassland emissions are negligible. Settlements and Forest Land act as carbon sinks, with consistent sequestration of approximately 8,200 Gg and 1,800 Gg, respectively, throughout the period.

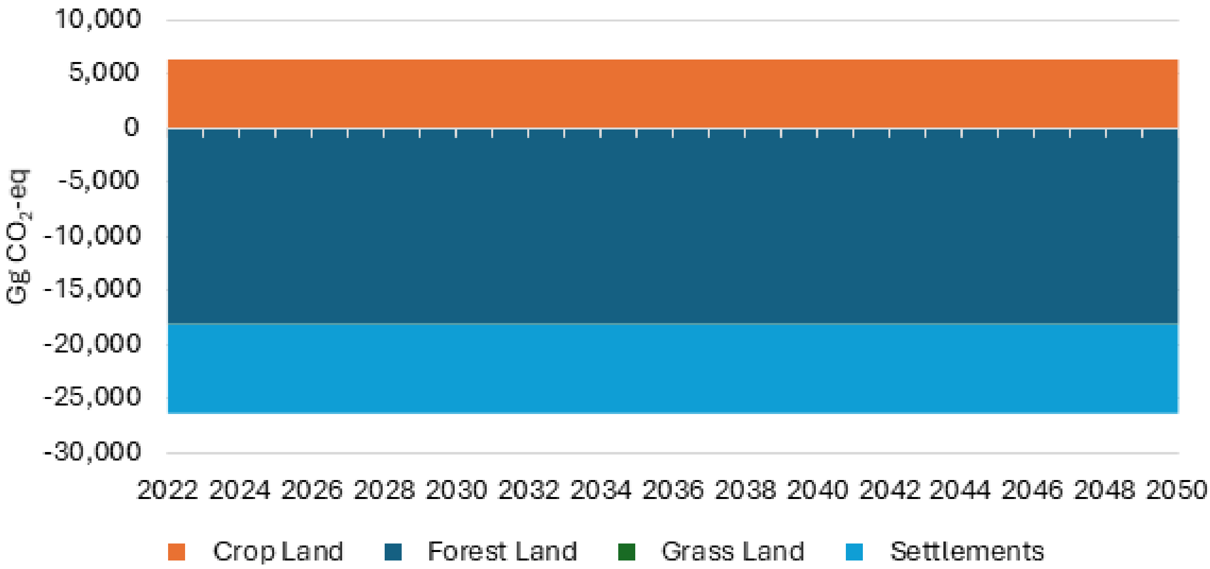


Figure 59: GHG emissions/removal projection from the land use sector

Waste

The waste sector's greenhouse gas (GHG) emissions are projected to rise significantly from 4,827.02 Gg CO_2-eq in 2022 to 11,859.60 Gg CO_2-eq in 2050, reflecting an average annual growth rate of approximately

3.3% per annum. Industrial wastewater treatment and discharge is the fastest-growing source, driven by expanding industrial activity. Domestic wastewater treatment and discharge grow steadily to 2,950 Gg CO_2-eq, at a moderate annual rate of around 1.5%, due to population growth and urbanization. Methane emissions from municipal solid waste in landfills increased to 2,047 Gg CO_2-eq, reflecting an annual growth of 1.5%, indicating continued reliance on landfilling. Emissions from incineration and open burning increase modestly to 165.9 Gg CO_2-eq, growing at 0.9% annually, while biological treatment of waste rises slightly to 20 Gg CO_2-eq, at an annual growth rate of 1.5%. These trends underscore the urgent need for effective waste management strategies, including methane capture, advanced treatment technologies, and waste minimization to curb emissions growth.

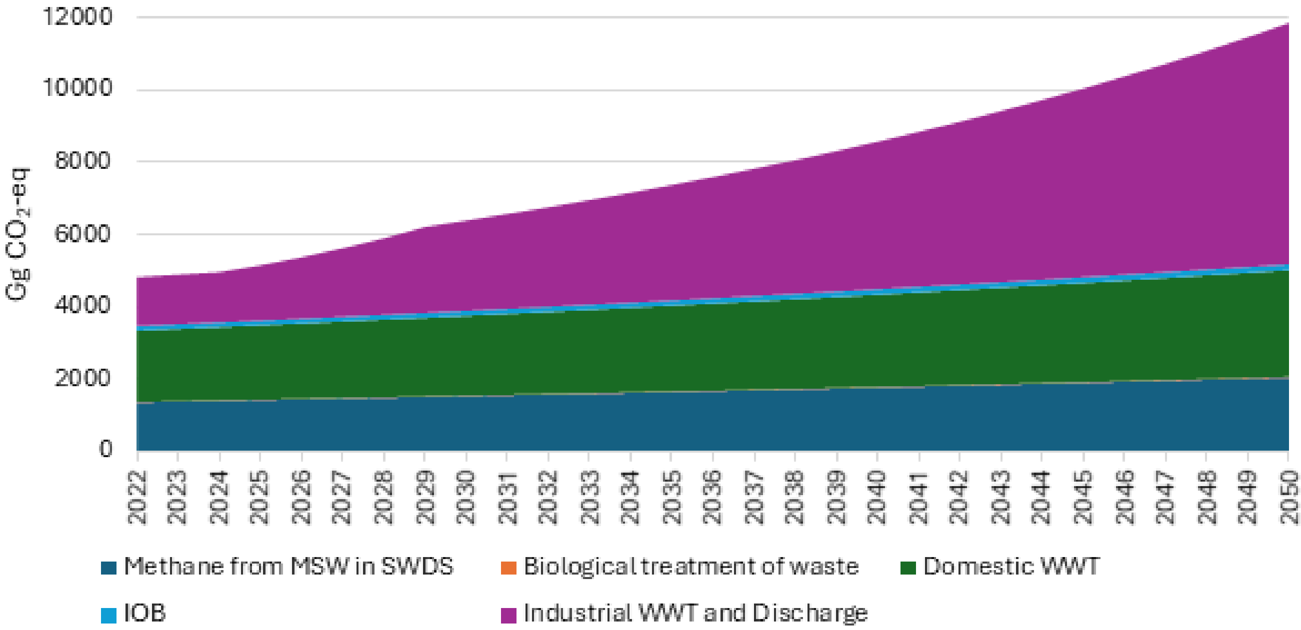


Figure 60: GHG emissions projection from the waste sector

3.12 Way forward – moving to higher tier

3.12.1 Way Forward for Next Tier Emission Inventory

In the current Greenhouse Gas (GHG) inventory study, the transition from Tier 1 to Tier 2 methodologies was not feasible for several logical and practical reasons:

- Data Gaps: A significant barrier was the lack of high-quality, granular, and specific data, such as detailed activity data, technologies, and localized emission factors. For several activities, the required detailed data was incomplete or inconsistent across the years. This lack of historical data made it impossible to consistently apply Tier 2 methodologies to estimate emissions accurately from 1994 onwards.
- Technical Complexity: Tier 2 methodologies are more complex and involve incorporating more specific emission factors, refined calculation methods, and a variety of additional parameters. Transitioning from the simpler Tier 1 methods to the more detailed Tier 2 approaches required significant adjustments to existing systems, which were technically challenging within the timeline of the current inventory. Furthermore, given the complexity of Tier 2 methodologies, there was potential for introducing uncertainties or errors in the results. Tier 1 methodologies, where the uncertainties are generally understood and more manageable, were thus advisable.
- Resource Constraints: Upgrading to Tier 2 requires considerable technical expertise and resources. The available human and financial resources were insufficient to support the extensive data collection, refinement, and methodology adaptation required for such a transition.
- Time Constraints: Since the inventory needed to cover emissions from 1994 onward, the time required to gather the data, apply Tier 2 methods, and ensure the accuracy of historical data would

have significantly impacted the process. The need to meet the requirements made it impractical to complete the Tier 2 upgrade within the given timeframe.

Nevertheless, it is now essential to move toward the higher-tier methodologies for given reasons:

- Enhanced Accuracy and Precision: Tier 2 offers more accurate and detailed emissions estimates by using specific local data. This leads to better-informed decision-making and climate change.
- Improved Transparency and Credibility: A Tier 2 inventory is more transparent and credible, as it relies on refined data and clear methodologies. This improves the inventory's acceptance in international reviews.
- Better Policy Design and Monitoring: With more precise emissions data, the country can implement targeted policies and track progress toward climate goals more effectively. It allows for a deeper understanding of sectoral contributions to emissions.

Given is the recommended conceptual framework for the steps for transitioning from Tier 1 to Tier 2:

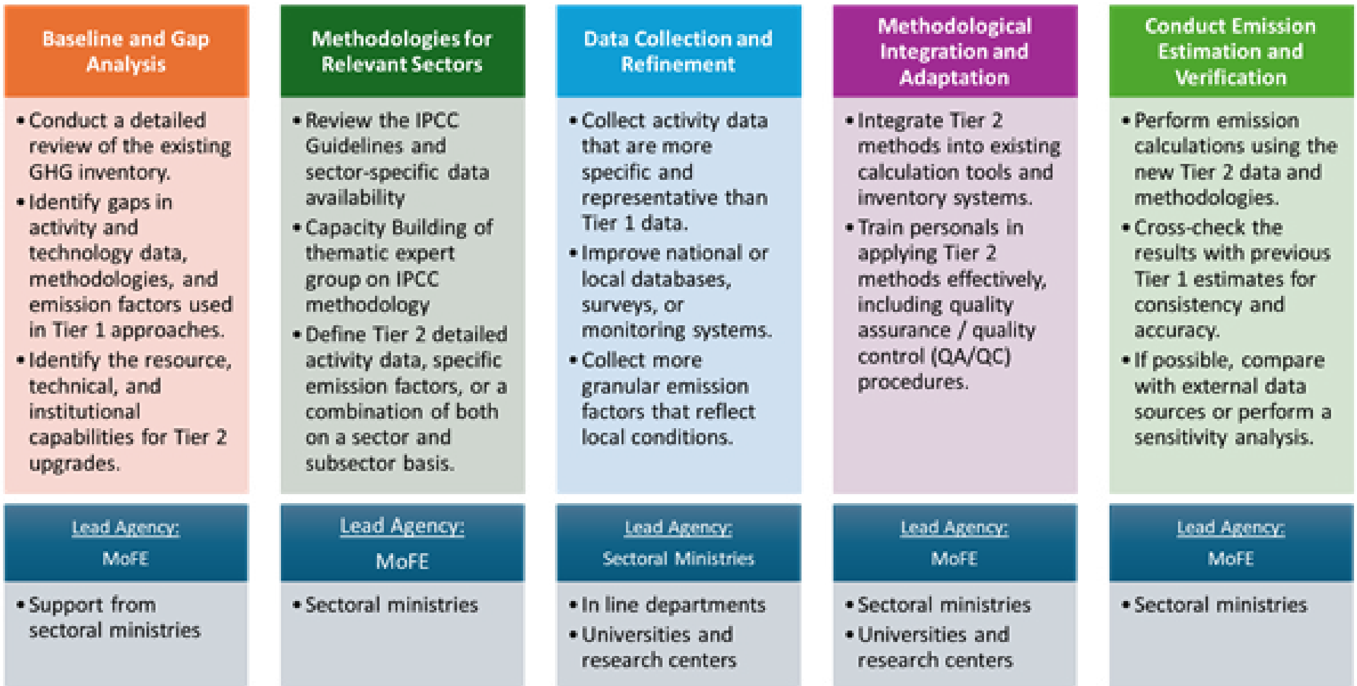


Figure 61: Conceptual framework for the steps for transitioning from Tier 1 to Tier 2

In order to effectively address climate change and meet national and international climate commitments, it is underlined that a comprehensive framework should be established, complemented by a robust Monitoring, Reporting, and Verification (MRV) system. This framework is expected to provide guidelines and standardized methodologies for sectoral agencies, responsible for key economic sectors such as energy, transportation, agriculture, and industry, to systematically collect, analyze, and report emissions data.

By equipping sectoral agencies with the necessary tools and processes, this approach will enable them to gather appropriate and high-quality data, conduct thorough analyses to identify emission trends and mitigation opportunities, and contribute to the accurate estimation of national emissions. Such a system will not only enhance the transparency and reliability of emissions data but also empower sectoral agencies to take ownership of their emissions management, ultimately supporting informed decision-making, effective policy implementation, and progress tracking toward national climate goals.

This integrated framework, combined with a rigorous MRV system, is essential for building a cohesive and actionable strategy to reduce greenhouse gas emissions and achieve sustainable development objectives. Since the end of 2024, Nepal has begun implementing the CBIT project, which aims to support capacity building and establish an operational MRV system. This system will play a crucial role in preparing subsequent GHG inventories and meeting Nepal's other reporting requirements.

4 Information Necessary to Track Progress Made in Implementing and Achieving Nationally Determined Contributions Under Article 4 of the Paris Agreement

4.1 National Circumstances and Institutional Arrangements

The Climate Change Management Division under the Ministry of Forests and Environment is the lead coordinating body responsible for NDC formulation, implementation, and tracking progress. The National Council on Environment Protection and Climate Change Management was established, which oversees the integration of environmental and climate change matters into long-term policies, provides policy guidance to provincial and local levels, and manages resources for climate actions. The Inter-Ministerial Climate Change Coordination Committee provides strategic direction and ensures multi-sectoral coordination for the effective implementation of the NDC. Similarly, a sub-national mechanism was established in the province, which ensures NDCs are localized and effectively implemented in line with regional priorities. Forest, Environment and Disaster Management Section in Rural/Municipalities facilitates climate change activities, including movnitoring related to climate actions. Furthermore, development partners, civil societies, youth organizations, indigenous groups, private sectors, academia, and media contribute to the implementation of NDC targets.

The detailed national circumstances are included in Chapter 1.

4.2 Description of NDC under Article 4 of the Paris Agreement

Recognizing the disproportionate risks posed by climate change, Nepal has aligned its national climate ambition with the 1.5°C temperature goal of the Paris Agreement. The Government of Nepal is committed to pursuing low-carbon and climate-resilient development pathways while promoting sustainable development, equity, and inclusive participation. Nepal submitted its Second Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) in December 2020, marking a significant advancement in its climate commitments under Article 4.1, which encourages ambitious, voluntary mitigation measures tailored to national circumstances. The Second NDC (2020) reflects this commitment and builds upon Nepal's existing national policies, including the National Climate Change Policy (2019), the Environment Protection Act (2019), and the Fifteenth Development Plan (2019/20–2023/24). It was developed through an inclusive, consultative, and country-driven process and is supported by both conditional and unconditional commitments. This NDC enhances ambition and expands sectoral coverage compared to the 2016 First NDC, aligning with Nepal's goal of achieving net-zero greenhouse gas emissions by 2050.

4.2.1 Target(s) and Description

Nepal's Second Nationally Determined Contribution (NDC), submitted in December 2020, outlines sectoral activity-based targets and policy objectives aimed at reducing greenhouse gas emissions and fostering low-carbon development across key priority sectors. These targets include emission reductions below business-as-usual (BAU) scenarios in sectors such as transport, energy, and residential cooking; mitigation co-benefits through actions like sustainable forest management and electric public transportation; and policy-based commitments that support institutional reforms and infrastructure development, such as urban planning and industrial emission guidelines. Key targets include expanding clean energy generation from 1400 MW to 15000 MW by 2030, with 5000 MW being unconditional. In the transport sector, Nepal aims for 90% of new private vehicle sales and 60% of four-wheeler public vehicle sales to be electric by 2030. For residential cooking, the target is to have 25% of households using electric stoves by 2030. In the forestry sector, the goal is to maintain 45% forest cover and sustainably manage 50% of Tarai forests and 25% of Hill/Mountain forests. Regarding waste management, Nepal aims to treat 380 million liters of wastewater per day and manage 60,000 cubic meters of faecal sludge annually by 2025.

4.2.2 These targets consist of both unconditional and conditional commitments. Unconditional targets are those Nepal aims to achieve using its own domestic resources, while conditional targets rely on the availability of international support, including financing, technology transfer, and capacity building. Reference Point(s), Level(s), Baseline(s), Base Year(s), and Their Respective Value(s)

Nepal uses 2011 as the base year for its emissions reference, in alignment with the national Greenhouse Gas Inventory developed for the Third National Communication. The net greenhouse gas (GHG) emissions for the base year were 31,998.91 Gg CO_2 equivalent, with sector-wise emissions as follows: Energy contributed 14,713.36 Gg CO_2 eq, Industrial Processes and Product Use (IPPU) accounted for 379.80 Gg CO_2 eq, Agriculture, Forestry and Other Land Use (AFOLU) emitted 15,982.16 Gg CO_2 eq, and the Waste sector contributed 923.59 Gg CO_2 eq. In terms of sectoral reference levels, the current energy generation in 2020 was approximately 1,400 MW, the share of electric vehicles is around 1%, forest cover is at 44.74% with a target to maintain 45% by 2030, and only 2.1% of wastewater is currently treated.

Table 44: Sectoral Targets in Second NDC

Sector	Targets	Unit	Reference year	Reference value	Target value
Energy	Expand clean energy generation from approximately 1,400 MW to 15,000 MW by 2030	MW	2020	1400	15000
Transport	Sales of electric vehicles (Private Passenger vehicle including two-wheelers)	% %	2020 2020		20
	Sales of electric four-wheeler public passengers' vehicle	%	2020		90
	By 2030:			N/A	60
	Increase sales of private e-vehicle including two-wheelers	%	2020		
	Sales of electric four-wheeler public passenger vehicle				
	Develop 200 KM of electric rail network	KM	2020		200
Residential Cooking and biogas	By 2030, ensure 25% of household use electric stoves as their primary mode of cooking.	%	2020	5	25
	By 2025, install 500000 improved cookstoves	Numbers			500000
	By 2025, install an additional 200000 household biogas plants and 500 large scale biogas plants (Institutional/industrial/municipal/community)	Numbers			200000 (household biogas) & 500 large scale biogas
IPPU					

Agriculture	By 2030, soil organic matter content of agriculture land will reach to 3.95%	%	2020	2	3.95
	By 2030, mulberry and fruit orchard areas will be expanded to 6000 ha.	Ha	2020		6000
	By 2030, the number of additional improved cattle sheds will reach to 500000 for quality farm-yard manure production and use.	Number	2020	1000000	500000
	By 2030 the number of organic fertilizer production plants in the country will reach 100.	Number	2020	23	100
Forestry	Maintain 454% forest cover, promote sustainable forest management, and enhance carbon sequestration through forest-based solutions	%	2020	44.74	454
Waste	By 2025, 380 million liters/day of wastewater will be treated before being discharged and 60000 cubic meters/year of faecal sludge will be managed.	Liters/day meters/ day	2020 2020	2.1% <1%	380 million 60000 cubic meters/year

4.2.3 Target Year(s) or Period(s), and Whether They Are Single-Year or Multi-Year

The implementation period for Nepal's Second Nationally Determined Contribution (NDC) spans from 2021 to 2030. Nepal has established a single-year target for 2030, supported by interim milestones set for 2025 to guide and track progress toward the long-term goals.

4.2.4 Time Frame(s) and/or Periods for Implementation

The implementation period for this NDC is 1 January 2021 to 31 December 2030, consistent with Decision 1/CP.21 and Article 4 of the Paris Agreement.

4.2.5 Scope and Coverage

Nepal's Second Nationally Determined Contribution outlines commitments across several key sectors, including Energy (generation, transport, residential cooking), Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU), and Waste. The greenhouse gases covered under this plan are Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O).

4.2.6 Intention to Use Cooperative Approaches Under Article 6

Nepal has expressed its intention to explore the use of internationally transferred mitigation outcomes (ITMOs) under Article 6 of the Paris Agreement to enhance mitigation ambition, promote sustainable development, and ensure environmental integrity. The country remains open to participating in voluntary carbon markets that are aligned with the mechanisms outlined in Article 6.2 and 6.4 of the Agreement.

4.2.7 Any Updates or Clarifications of Previously Reported Information

Nepal's 2020 NDC represents a significant enhancement over its first NDC submitted in 2016. It features expanded sectoral coverage, now including land use change and forestry, energy, waste, and industrial processes and product use (IPPU). The updated NDC sets more ambitious targets, with higher quantitative commitments in areas such as renewable energy generation, electric vehicle adoption, and sustainable forest management. Methodologies have also been clarified, with alignment to the 2006 IPCC Guidelines using Tier 1 and some Tier 2 approaches and structured to comply with the Information to Facilitate Clarity, Transparency, and Understanding (ICTU) requirements. Additionally, the 2020 NDC incorporates new modeling through the Low Emissions Analysis Platform (LEAP) and reflects updated consultations with a broad range of stakeholders, including youth, women, and Indigenous Peoples. Nepal has indicated that it may revise and update its NDC as more robust national data and updated greenhouse gas inventories become available.

4.3 Tracking Progress towards implementation and achieving the NDC

The following table shows progress with some of the key quantifiable targets. This report includes Common Tabular Formats (CTFs) of these targets as supplementary material.

Table 45: Targets and progress of some of the key quantifiable targets in Nepal's NDC

Sector	Target/Indicator	Unit	Information to track progress	Progress made in 2025
Energy	By 2030, expand clean energy generation from approximately 1,400 Megawatts (MW) to 15,000 MW, of which 5-10 % will be generated from mini and micro-hydro power, solar, wind and bioenergy. Of this, 5,000 MW is an unconditional target.	MW	Installed capacity of clean and renewable electricity generation from 2021 to January 2025. • Grid-connected Solar: 81.9 MW • Off-grid Solar: 80 MW • Micro/Mini Hydro: 40.253 MW • Solar Mini-grid + Wind: 3.097 MW • Urban Solar: 10.08 MW	3450 (23%) till January 2025 (DoED, 2025)
	By 2030, ensure 15% of the total energy demand is supplied from clean energy sources	%	Share of clean energy and renewal energy	10.33% of total energy demand generated through clean and renewable energy (DoED, 2025)
	Sales of electric vehicles (e-vehicles) in 2025 will be 25% of all private passenger vehicles sales, including two-wheelers, and 20% of all four-wheelers' public passenger vehicle sales By 2030, increase sales of e-vehicles to cover 90% of all private passenger vehicle sales, including two-wheelers, and 60% of all four-wheelers' public passenger vehicle sales Note: these private and public passenger targets do not consider electric rickshaws and electric tempos.	%	Private passenger vehicles: All four-wheeler and two-wheeler private passenger vehicles imported were electric vehicles (DOC, 2023). • Total electric four-wheelers vehicle imported in FY 2022/23. • Two-wheelers electric vehicle imported in FY 2022/23.	12.38% 46% 9.6%

	Public passenger vehicles: 281 (29%) out of a total of 963 four-wheelers imported were EVs in FY 2022/23 (DOC, 2023).		• Nepal has met the 2025 target for public passenger vehicles well ahead of time • It is important to sustain the growth in the use of electric public passenger vehicles to meet the 2030 target	
	By 2030, develop 200 km of the electric rail network to support public commuting and mass transportation of goods.	KM	• Total electric rail network. • The China-Nepal railway and the Metrorail in Kathmandu have been planned.	112 km of railway track has been laid, 52 km of diesel-electric railway in operation (MoPIT, 2023)
	By 2030, ensure 25% of households use electric stoves as their primary mode of cooking	%	• Households use electric stoves in addition to other stoves (NSO, 2022); however, data on use of electric stoves as primary mode of cooking is not available.	
	By 2025, install 500,000 improved cookstoves (ICS), specifically in rural areas.	Numbers	• Nepal imported 130,745 Induction Stoves, 73,648 infrared cookers, and 2,294 other electric stoves in the FY 2022/23 (DOC, 2023).	
	By 2025, install an additional 200,000 household biogas plants and 500 large scale biogas plants (institutional/ industrial/ municipal/ community).	Numbers	Domestic Biogas: • Total additional installed domestic biogas plants. Large-Scale Biogas: • Total installed large scale biogas plants.	21,806 by July 2023. (AEPC, 2024) 357 (71%) till July 2023. (AEPC, 2023)
	By 2030, maintain 45% of the total area of the country under forest cover (including other wooded land limited to less than 4%).	%	• Total area of the country under forest cover, including other wooded land	46.08% including other wooded land of 2.8% (FRTC, 2024)
	By 2025, 380 million liters/ day of wastewater will be treated before being discharged, and 60,000 cubic meters/year of fecal sludge will be managed	liters/day	Wastewater treatment: • Total wastewater treated per day before being discharged Fecal Sludge Management: • 2.13% of the population had access to a sewerage system with fecal sludge management till July 2022 (DWSSM, 2023). • In the nascent stage, with approx. 5 municipal level plants treating a total of 250 cubic meters/ year of fecal sludge.	50 million liters/day

4.3 Mitigation policies and measures, actions and plans, including those with mitigation co-benefits resulting from adaptation actions and economic diversification plans, related to implementing and achieving a nationally determined contribution under Article 4 of the Paris Agreement

Nepal has demonstrated a strong commitment to climate change mitigation under Article 4 of the Paris Agreement through a range of national policies, measures, and plans aligned with its nationally determined contributions (NDCs). The country's Second NDC (2020) outlines ambitious targets to achieve net-zero emissions by 2045, with key mitigation actions in the energy, transport, agriculture, forestry, and waste sectors. Nepal aims to increase the share of clean energy in its energy mix, promote electric vehicles (targeting 90% electric public transport by 2030), and adopt sustainable agricultural practices. The Forestry Sector Strategy and REDD+ Implementation Framework emphasize enhancing forest carbon stocks through community-based forest management and afforestation programs, contributing significantly to mitigation. Adaptation actions in climate-resilient agriculture, watershed management, and ecosystem-based approaches also generate mitigation co-benefits, such as increased carbon sequestration and reduced land degradation. Additionally, Nepal's Climate Resilient Planning and Green, Resilient, Inclusive Development (GRID) Framework integrates economic diversification with low-carbon growth. These efforts, supported by legal instruments like the Climate Change Policy (2019) and Environmental Protection Act (2019), reflect Nepal's proactive role in aligning national development priorities with its climate goals and obligations under the Paris Agreement.

Long-term Strategy for Net Zero Emissions, 2021

Nepal is firmly committed to advancing climate action under the Paris Agreement, following the principle of common but differentiated responsibilities. It aims to achieve net-zero by 2045. Nepal also seeks recognition for its contributions to global mitigation through clean energy exports. The Long-Term Strategy (LTS) envisions a climate-resilient, inclusive, and carbon-neutral future driven by bold policy reforms, social transformation, and technological progress. In 2019, Nepal's total carbon dioxide (CO_2) emissions were 23 million metric tons (mMtCO_2), projected to increase to 34 mMtCO_2 by 2030 and 79 mMtCO_2 by 2050 under the reference scenario. Emissions were nearly evenly split between energy (54%) and non-energy sectors (46%). Land Use, Land Use Change, and Forestry (LULUCF) emissions stood at 8 mMtCO_2 in 2019, expected to rise to 17 mMtCO_2 by 2050. Under the "With Existing Measures" (WEM) scenario, net emissions are reduced by 30 mMtCO_2 by 2030 and 50 mMtCO_2 by 2050. The energy sector is the main contributor to this reduction, while LULUCF serves as a key carbon sink, though its sequestration capacity gradually declines after 2030. Consequently, net emissions are expected to rise by 11% annually post-2030. "With Additional Measures" (WAM) scenario demonstrates Nepal's most ambitious path, combining deeper energy reforms and enhanced carbon sequestration. This scenario projects net-negative emissions between 2020 and 2030, stabilization around net-zero through 2045, and reaching -5.7 mMtCO_2 by 2050. These projections highlight Nepal's high potential for emission reductions with strategic interventions.

Key sectoral strategies include:

Energy: The highest emissions come from residential, transport, industrial, and agricultural uses. The strategy emphasizes shifting to electric cooking, clean transport, efficient brick kiln technologies, and powering all sectors with hydropower, solar, and hydrogen energy.

Industrial Processes and Product Use (IPPU): Though emissions are currently low, anticipated industrial growth requires transitioning to clean fuels and raw materials, including potential use of carbon capture technologies.

AFOLU: Agriculture strategies focus on improved cultivation practices, soil and manure management, sustainable fertilizer use, and agroforestry. Forestry strategies aim to increase forest cover, prevent deforestation, manage forest fires, promote private forestry, and enhance MRV systems.

Waste: Reducing emissions from waste involves promoting methane recovery, waste-to-energy incineration, and anaerobic digestion technologies.

Energy Trade: Exporting clean hydropower and solar energy can help reduce emissions regionally, though these are not currently part of Nepal's national emissions accounting.

The LTS implementation relies on strong institutional coordination, private sector engagement, and a robust MRV system. Financial resources are critical to realizing these ambitions. Estimated investments vary across scenarios: under WAM, total costs could reach $46.4 billion (2021–2030), $53.4 billion (2031–2040), and $96.3 billion (2041–2050), all in constant 2000 USD.

National Climate Change Policy, 2019

The National Climate Change Policy, 2019, establishes a strategic framework to address climate change impacts and advance Nepal's transition to a climate-resilient, low-carbon society. Anchored in the overarching goal of fostering socio-economic prosperity through enhanced resilience and sustainable development, the policy prioritizes six core objectives: strengthening adaptive capacity for vulnerable populations and ecosystems, promoting green economic growth via renewable energy and climate-smart practices, mobilizing domestic and international climate finance, advancing research and technological innovation, mainstreaming climate considerations across governance tiers, and ensuring gender equality and social inclusion in all climate actions. These objectives aim to mitigate risks posed by climate variability while aligning Nepal's development trajectory with global climate commitments, including the Paris Agreement and Sustainable Development Goals (SDGs).

To operationalize these objectives, the policy outlines sector-specific and cross-cutting strategies. Key sectors such as agriculture, water resources, infrastructure, and public health are targeted for climate-resilient interventions, including sustainable farming practices, watershed conservation, disaster-resilient infrastructure, and health risk mitigation. Cross-cutting themes emphasize equity, governance, and awareness, ensuring marginalized groups such as women, Indigenous Peoples, and rural communities participate in decision-making and benefit from climate programs. Additionally, the policy promotes research institutions, technology innovation, and capacity-building initiatives to bridge knowledge gaps and empower stakeholders. Financial mechanisms, including the Climate Change Fund and international partnerships, are prioritized to secure resources for implementation, while legal reforms and climate-responsive budgeting aim to institutionalize long-term resilience.

The policy further defines roles for federal, provincial, and local governments to ensure coordinated action, with federal bodies overseeing national strategy and international cooperation, provincial governments tailoring plans to regional contexts, and local governments leading community-based adaptation. A dedicated Climate Change Coordination Committee ensures inter-sectoral collaboration, while robust monitoring and evaluation frameworks track progress through biennial reports and audits. By integrating climate resilience into Nepal's developmental fabric, the policy seeks to safeguard natural and cultural heritage, reduce disaster risks, and achieve equitable, sustainable growth.

National Adaptation Plan, 2021

Nepal's National Adaptation Plan (NAP) outlines the country's strategic framework to address the growing challenges posed by climate change by enhancing adaptation capacity and building climate resilience across all sectors and governance levels. Recognizing the limited scientific, technical, and economic resources that constrain Nepal's ability to respond effectively to climate-induced risks, the NAP aims to close critical gaps in climate impact measurement, adaptation planning, and resilience-building. Rooted in the National Climate Change Policy (2019) and aligned with Nepal's Nationally Determined Contribution (2020), the NAP sets out long-term goals to 2050, with medium- and short-term actions planned up to 2040 and 2030 respectively. It also serves as Nepal's official Adaptation Communication under the UNFCCC's Paris Agreement.

The NAP identifies 64 priority programmes covering nine thematic sectors, including agriculture, water, forests, urban and rural settlements, infrastructure, tourism, health, disaster risk reduction, and gender equality and social inclusion. These programmes were developed through an inclusive, multi-stakeholder consultation process and aim to mainstream adaptation measures into national policies, plans, and development efforts. A total budget of USD 47.4 billion is estimated for implementation, with Nepal contributing USD 1.5 billion and the remainder expected from external sources. The plan emphasizes integration of gender and social inclusion, climate science, and ecosystem-based approaches, and requires an annual investment of USD 2.1 billion to meet its objectives.

Implementation and oversight of the NAP involve various institutional mechanisms including the Environmental Protection and Climate Change Management National Council, the Inter-Ministerial

Climate Change Coordination Committee, and thematic and cross-cutting working groups. The Ministry of Forests and Environment leads coordination, supported by the National Planning Commission, Ministry of Finance, and sectoral ministries, along with engagement from civil society, academia, development partners, and the private sector. A comprehensive review will occur every five years, with a major update scheduled for 2031 to ensure alignment with evolving national and global contexts, development priorities, and climate realities.

Nepal National REDD+ Strategy, 2018

Nepal's REDD+ Strategy 2018 is a comprehensive framework for mitigating climate change through forest-based actions, aiming to reduce emissions from deforestation and forest degradation while simultaneously enhancing carbon stocks and promoting sustainable forest management. The strategy's vision centers on leveraging the carbon and non-carbon benefits of Nepal's forest ecosystems to contribute to the prosperity of its people. The overall goal is to reduce carbon emissions, enhance carbon stocks, and improve ecosystem resilience by addressing the drivers of deforestation and degradation, promoting sustainable practices in both agriculture and forestry.

The strategy outlines several key strategic objectives, including reducing deforestation and degradation, promoting sustainable forest management, enhancing carbon stocks through afforestation and reforestation, and addressing the underlying drivers of forest loss. It emphasizes the importance of robust governance and institutional arrangements, ensuring social and environmental safeguards, and promoting equitable benefit sharing mechanisms that prioritize forest-dependent communities. Furthermore, the strategy aims to enhance livelihoods through alternative income opportunities, build the capacity of stakeholders, establish a transparent Monitoring, Reporting, and Verification (MRV) system, and integrate forest management with broader land-use planning.

Nepal has made significant progress in its REDD+ readiness, building upon its strong foundation of community forestry. The strategy's implementation involves a multi-tiered institutional mechanism at the national level and emphasizes the active participation of local communities, Indigenous Peoples, civil society organizations, and the private sector. Nepal is currently implementing its Emission Reduction Program in the Tarai Arc Landscape, showcasing its commitment to achieving tangible emission reductions and accessing performance-based payments, ultimately contributing to both global climate goals and local sustainable development.

National Energy Efficiency Strategy, 2019

Nepal's National Energy Efficiency Strategy, 2075, outlines a plan to address the nation's energy challenges and promote efficient energy use. It emphasizes the need for policy, legal, and institutional frameworks to ensure affordable and reliable energy, aligning with Nepal's goals to achieve the UN's Sustainable Development Goals. The strategy builds upon past energy efficiency efforts and aims to integrate energy efficiency into the broader energy system, moving beyond isolated initiatives.

The strategy envisions enhanced energy security through increased energy access and efficient energy use. A key goal is to double the average annual improvement rate of energy efficiency by 2030. Objectives include supporting economic growth by reducing energy intensity, increasing energy access, creating employment opportunities in the energy efficiency market, and promoting environmental balance.

To achieve these objectives, the strategy proposes several key actions, including raising energy efficiency awareness, establishing policy and legal frameworks, developing national energy efficiency standards, making services and production cost-effective by reducing energy consumption, and reducing energy imports through conservation. Implementation involves sector-wise management at local, provincial, and federal levels, time-bound measures, and stakeholder participation. The strategy also addresses legal and institutional structures, financial aspects, research and development, and monitoring and evaluation mechanisms.

The Sixteenth Plan (Fiscal Year 2024/25 – 2028/29)

Chapter 13 of Nepal's 16th Five-Year Plan addresses the critical nexus of biodiversity, climate change, and the green economy, recognizing their integral role in achieving a healthy and prosperous nation. The chapter highlights Nepal's unique opportunities in leveraging its natural resources through sustainable management, biodiversity conservation, clean energy transition, and eco-tourism. While acknowledging Nepal's minimal contribution to global greenhouse gas emissions, it underscores the significant impacts of climate change on the country, including glacial melt, altered weather patterns, and increased natural disasters, which disproportionately affect vulnerable communities. The plan emphasizes the need for a green, resilient, and inclusive economic model that ensures the continuity of ecosystem services and prioritizes climate sensitivity in all development endeavors, building upon Nepal's existing efforts and its standing in the international forum for environmental conservation.

To tackle these challenges and harness opportunities, the plan outlines several transformative strategies aimed at fostering climate resilience and inclusive development through environmentally conscious investments and enhanced adaptive capacities at all levels. It emphasizes the internationalization of Nepal's climate change concerns by actively engaging in global forums and advocating for the needs of vulnerable nations. Pollution control is identified as a key strategy for ensuring a healthy society, focusing on effective monitoring, investment in clean technologies, and the enforcement of the "polluter pays" principle. Sustainable forest management is prioritized for both environmental benefits and green economic development, aiming to increase carbon stocks and promote forest-based enterprises. Biodiversity conservation is addressed through the protection of endangered species, habitat preservation, and the mitigation of human-wildlife conflict. Furthermore, the plan seeks to promote a green economy by capitalizing on Nepal's comparative advantages, increasing access to climate finance, and mainstreaming environmental considerations into all sectors, supported by enhanced research, policy reforms, and institutional capacity building.

To operate these transformative strategies, the plan proposes a range of major programs. These include initiatives to promote a green economy through financial incentives and support for clean energy and sustainable practices, alongside programs for the sustainable management and commercial use of forests, aiming for self-reliance in timber and the development of herbal products. The plan also outlines programs for the sustainable conservation of biodiversity by expanding eco-tourism and protecting ecosystems, as well as pollution control programs focused on setting emission standards and improving waste management. Recognizing the urgency of climate impacts, the plan includes programs for reducing climate risks and losses through early warning systems and resilient infrastructure, alongside local adaptability promotion programs to build capacity at the grassroots level. It also emphasizes programs to increase access to international climate finance, strengthen research and monitoring systems, and implement policy reforms and institutional capacity development to effectively address the interconnected challenges of biodiversity loss, climate change, and the transition to a green economy in Nepal.

Forestry Sector Strategy, (2016-2025)

The Forestry Sector Strategy (FSS) for Nepal, spanning the next ten years, is a comprehensive document formulated to guide the future development of the nation's forestry sector. Rooted in the Forest Policy 2015 and drawing lessons from the preceding Master Plan for the Forestry Sector, which concluded in 2011, the FSS envisions the evolving political and socio-economic landscape of Nepal and establishes a theory of change outlining the steps towards planned outcomes. The strategy is structured into four parts, beginning with an introduction, followed by the vision for Nepal's forestry sector, a detailed description of actions and approaches across seven key thematic areas to achieve this vision, and finally, the delivery mechanisms for implementation, with supporting annexes. Integral to all seven thematic areas are eight strategic pillars: sustainably managed resources and ecosystem services; conducive policy process and operational environment; responsive and transparent organizations and partnerships; improved governance and effective service delivery; security of resource use by the community; private sector engagement and economic development; gender equality, social inclusion, and poverty reduction; and climate change mitigation and resilience.

The overarching vision of the FSS is the sustainable management of forest ecosystems, biodiversity, and watersheds, fully optimized for national prosperity. This vision is supported by the goal of ensuring that forests, biodiversity, plant resources, wildlife, watersheds, and other ecosystems are protected, sustainably managed, and made climate-resilient through an inclusive, decentralized, competitive, and well-governed forestry sector that provides equitable employment, incomes, and livelihoods. The FSS aims to deliver five major outcomes: sustainable production and supply of forest products; improvement of biodiversity, watersheds, and ecosystem services; increased contribution to national economic development; inclusive and accountable forestry sector institutions and organizations; and a climate-resilient society and forest ecosystems. Milestones are established to monitor progress towards these outcomes, with a mid-term review planned to assess achievements and implement necessary corrective actions. The seven key thematic areas forming the core of the strategy are: managing Nepal's forests; managing ecosystems and conserving biodiversity; responding to climate change; managing watersheds; promoting enterprise and economic development; enhancing capacities, institutions, and partnerships; and managing and using forestry sector information, each further divided into program areas.

The implementation of the FSS, detailed in its fourth part, 'delivering the vision,' is guided by principles, defined institutional roles and responsibilities, and specific implementation methods. This section also elucidates the relationship between the eight strategic pillars and the approaches adopted to implement the strategies across the seven thematic areas. The annexes provide supplementary information, including the roles, functions, and responsibilities of various actors, priority programmes and strategic interventions tailored to different ecological zones, and a comprehensive monitoring framework. The strategies related to each theme are elaborated in Part three, providing a detailed roadmap for achieving the FSS's vision and goals through coordinated actions and approaches across Nepal's diverse forestry sector.

National Environment Policy, 2019

The National Environment Policy 2019 aims to ensure the citizens' right to live in clean and healthy environment by controlling pollution, waste management and promoting greenery. It spells out the nation's policies, strategies and action plans on six different areas: a) prevention, control and minimization of pollution, b) environmental mainstreaming, c) environmental justice, d) public participation, e) sustainable development and f) good governance, research and capacity building in environmental sector. The policy emphasizes preventing, controlling and minimizing all types of pollution including water, air, soil, sound, electromagnetic radiation, chemical and radioactive, mainstreaming environmental concern on all kinds of development initiatives, assessing environmental and social impacts of policies, programs and projects and minimizing their adverse impacts and augmenting their positive impacts and ensuring environmental justice to victims of environmental adversities.

The major strategies and action plans on pollution control include formulating concentration-based and load-based standards for pollution control, using latest methods like dispersion modeling for emission field mapping, source apportionment for pollution control, establishment of combined incineration plant for disposal of waste generated from industries, hospitals or other special locations, controlling sewage discharge into river, giving due consideration to minimizing adverse downstream impacts of disposing solid and liquid waste in the watershed area. Prior to implementation of a proposal, the proponent will be made liable to conduct relevant environmental study based on the environmental thresholds and to allocate necessary budget for mitigating adverse impacts and enhancing positive impacts in the study report. Likewise, review and approval process of environmental study reports will be made transparent and simple. Environmental monitoring and audit will be carried out to assess the status of implementation of environmental study reports.

This policy identifies the roles of federal, provincial and local governments in implementation of this policy. The federal level will formulate national level policies, laws, standards and regulatory mechanisms. The province is authorized to establish provincial level environmental standards adhering to the federal standards. The province also carries out studies, regulations and monitoring for the environmental impacts of development projects implemented by the province. The local level will implement the national policies and strategies on environmental conservation and management at the local level. According to the policy, the local government will keep a record of, regulate, and monitor projects implemented at a local level. The local level will monitor the implementation of the approved IEE report in local-level development projects.

National Forest Policy, 2019

The National Forest Policy 2019 aims to promote sustainable management of forest resources and enhance forest productivity. It places strong emphasis on soil and water conservation at the watershed level, advocating for planning and studies based on catchment areas. To support these goals, the policy encourages forest user groups to adopt scientific forest management practices that help strengthen ecosystems and enhance the provision of environmental services. Furthermore, the policy highlights the importance of land use planning and prioritizing the conservation of biodiversity, ecosystems, and genetic resources. It calls for the effective production and utilization of forest resources while integrating forest management, biodiversity conservation, and community development in a holistic and coordinated manner.

The Environment Protection Act, 2019 (2076)

The Environment Protection Act, 2019 (2076) establishes a foundational legal framework and mandates proactive engagement in understanding and addressing climate change impacts. It requires the Ministry to undertake studies to assess and disseminate information regarding the impacts of climate change on local communities, ecosystems, and biodiversity, thereby emphasizing the assessment of national vulnerabilities. The legislation further directs governmental bodies at the federal, provincial, and local levels to formulate and implement adaptation plans. These plans are mandated to prioritize the needs of vulnerable populations, including women, persons with disabilities, children, and economically disadvantaged communities, acknowledging their disproportionate susceptibility to the adverse effects of climate change.

With respect to climate change mitigation, the Act empowers the Government of Nepal to identify sectors contributing to greenhouse gas emissions and to establish national reference emission levels. This provision constitutes a significant step towards the regulation and reduction of such emissions. The Act also permits the measurement of greenhouse gas emissions, and the implementation of programs designed to achieve their reduction. Notably, the legislation extends beyond domestic measures by incorporating provisions for participation in carbon trading mechanisms, thereby facilitating international collaboration and the potential for financial incentives in support of climate action initiatives.

Other policies, such as Forest Act, National Forest Policy, Industrial Enterprises Act, Agriculture Development Strategy (2015-2035); National Biodiversity Strategy and Action Plan (2014-2020); and The Environment Protection Act (2019) indirectly encourage sustainable development practices. These policies, while not solely focused on GHG mitigations, include provisions that can contribute to emissions reduction. For example, provisions for regulating emissions from industries and promoting sustainable energy use. Similarly, the Agriculture Development Strategy includes measures to minimize emissions from agricultural production through climate-smart agricultural practices and renewable energy use. These policies collectively support Nepal's broader climate goals by promoting the safe and sustainable use of technologies, energies, and agricultural and land use practices.

4.4 Summary of greenhouse gas emissions and removals

A comprehensive and accurate National Greenhouse Gas (GHG) Inventory is a critical instrument for understanding a nation's role in global climate change. It provides essential data to assess the emissions and removals of greenhouse gases, offering a baseline for tracking progress towards climate goals and identifying potential mitigation opportunities. Furthermore, a robust GHG inventory supports international reporting obligations, enhancing transparency and accountability in climate action efforts.

This report presents Nepal's National GHG Inventory, providing an in-depth assessment of the country's GHG emissions and removals across key sectors. These sectors include energy, industrial processes and product use (IPPU), agriculture, forestry, and other land use (AFOLU), and waste. The inventory spans the period from 1994 to 2022, offering insights into historical trends while laying the foundation for future climate projections and strategies.

Prepared under the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, this report estimates and reports emissions and removals for three key greenhouse gases: Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O). These emissions are analyzed across five primary sectors: Energy, Industrial Processes and Product Use (IPPU), Agriculture, Land Use, Land Use Change, and Forestry (FOLU), and Waste.

4.4.1 Key Category of GHG Inventory

The national greenhouse gas (GHG) inventory utilized the IPCC Tier 1 methodology to analyse key categories, focusing on both the level and trend of emissions, as outlined in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Key source analysis identifies categories that cumulatively contribute 95% of total emissions.

Key observations from the analysis include:

- Forest land remaining forest land (3.B.1.a) has shown a negative emission trend, indicating carbon sequestration. However, it still contributed 19.87% to the trend, reflecting the importance of sustainable forest management in mitigating GHG emissions.
- Settlements remaining settlements (3.B.5.a) also contributed significantly with negative emission trend of 16.86% share.
- Enteric fermentation (3.A.1), remain a significant contributor to GHG emissions. Enteric fermentation accounted for 9.77% of the emissions trend, reflecting the impact of livestock on methane emissions.
- Moderate contributions were observed from cropland remaining cropland (3.B.2.a) and grassland remaining grassland (3.B.3.a), with 9.32% and 6.67% shares, respectively. These reflect the effects of agricultural intensification on CO2 emissions.
- Cement production (2.A.1) has become a notable source of CO2 emissions contributing 8.6% share to the trend. This reflects the rapid growth of industrial activities and infrastructure development.
- Fossil Fuels in Manufacturing: Emissions from manufacturing industries and construction using solid fuels (1.A.2) have increased, contributing 7.57% to the emissions trend. This highlights the growing reliance on fossil fuels in industrial energy consumption.
- Road transportation (1.A.3.b) has also seen a rise in emissions, contributing 4.04% to the trend. This indicates the increasing use of liquid fuels in the transportation sector, driven by urbanization and economic activity.
- The "Other Sectors - Biomass (Solid Fuels)" category (1.A.4) shows significant emissions, contributing 2.80% to the emissions trend. This indicates the ongoing reliance on traditional biomass for energy in rural regions.
- Rice cultivation (3.C.7) contributed moderately, with a 1.96% share, indicating the ongoing influence of agricultural practices on methane emissions.
- Solid waste disposal (4.A) and wastewater treatment and discharge (4.D) have contributed to GHG emissions, with 1.98% and 1.94% shares, respectively. These emissions are linked to urbanization and population growth, which have increased waste generation and the need for wastewater treatment.

4.4.2 Uncertainty Assessment

Uncertainty evaluations were conducted for all sectors and categories in the GHG inventory, using the IPCC Tier 1 methodology. A 95% confidence interval was applied to quantify potential variations in the reported values. The main drivers of uncertainty in GHG emissions are the variability and reliability of two key components: activity data and emission factors. These factors are influenced by the quality, availability, and representativeness of the data for the specific conditions of the inventory. The combined uncertainty for the national GHG inventory was estimated for two key years: the base year 2012 and the end year 2022. The overall combined uncertainty was found to be 78.371%. Among the assessed categories, the highest uncertainty was observed in 3.C.5 - Indirect N_2O Emissions from Managed Soils, with an exceptionally high uncertainty of 515.28%. This indicates significant variability in either the activity data, emission factors, or both for this category. In contrast, the lowest combined uncertainty was recorded for 1.A.3.a.ii - Domestic Aviation - Liquid Fuels, at a much lower value of 5%, reflecting higher data accuracy and consistency in this category.

4.4.3 National Inventory for 2022

Nepal's total net GHG emissions amount to 38,211.96 Gg CO_2-equivalent, with the largest contributions from the energy sector (65.5%) and industrial processes and product use (IPPU), 12.6%. Emissions from agriculture, forestry, and other land use (AFOLU) make up to 9.3%, and the waste sector contributes 12.6%. The energy sector, driven by fuel combustion, is the largest emitter, reflecting Nepal's growing reliance on fossil fuels. IPPU emissions primarily come from the mineral industry, driven by industrial growth. AFOLU generates significant CH_4 and N_2O emissions from livestock and croplands but offsets a large share of emissions through CO_2 removals from forests (20,021.96 Gg CO_2). The waste sector's emissions stem from wastewater treatment and solid waste disposal, highlighting inefficiencies in waste management. Despite the carbon sink benefits of Nepal's forests, rising emissions from energy and industrial sectors emphasize the need for renewable energy, sustainable land-use practices, and improved waste management. Detailed emissions from each sector are provided in Table 2.

Table 46: National Inventory of GHGs in Nepal in 2022

Inventory Year: 2022	**Emissions (Gg)**				**Net GHG Emissions**
Categories	Net CO_2	CH_4	N_2O	HFC	(Gg CO_2 -eq)
Total National Emissions and Removals	- 1,474.073	1,235.852	19.115	0.013	38,211.962
1 - Energy	13,567.620	383.423	2.682	-	25,014.290
1.A - Fuel Combustion Activities	13,567.620	383.423	2.682	-	25,014.290
1.A.1 - Energy Industries	0.023	0.000	0.000		0.023
1.A.2 - Manufacturing Industries and Construction	6,999.824	2.157	0.301		7,140.070
1.A.3 - Transport	4,629.203	0.861	0.410		4,761.971
1.A.4 - Other Sectors	1,938.570	380.405	1.971		13,112.227
2 - Industrial Processes and Product Use	4,794.891	-	-	0.013	4,811.594
2.A - Mineral Industry	4,792.239	-	-	-	4,792.239
2.A.1 - Cement production	4,792.239				4,792.239
2.D - Non-Energy Products from Fuels and Solvent Use	2.652	-	-	-	2.652
2.D.1 - Lubricant Use	1.900				1.900
2.D.2 - Paraffin Wax Use	0.752				0.752
2.F - Product Uses as Substitutes for Ozone Depleting Substances	-	-	-	0.013	16.703
2.F.1 - Refrigeration and Air Conditioning				0.013	16.703
3 - Agriculture, Forestry, and Other Land Use	- 19,916.207	733.118	11.172	-	3,571.787
3.A - Livestock	-	649.999	1.976	-	18,723.500
3.A.1 - Enteric Fermentation		595.951			16,686.635
3.A.2 - Manure Management		54.048	1.976		2,036.865
3.B - Land	- 20,021.958	-	-	-	-20,021.958
3.B.1 - Forest land	- 18,072.100				-18,072.100
3.B.2 - Cropland	6,345.516				6,345.516
3.B.3 - Grassland	- 38.794				- 38.794
3.B.5 - Settlements	- 8,256.580				-8,256.580
3.C - Aggregate sources and non-CO2 emissions sources on land	105.751	83.119	9.197	-	4,870.245
3.C.2 - Liming	0.531				0.531
3.C.3 - Urea application	105.220				105.220
3.C.4 - Direct N2O Emissions from managed soils			6.314		1,673.181

3.C.5 - Indirect N2O Emissions from managed soils			2.576		682.552
3.C.6 - Indirect N2O Emissions from manure management			0.307		81.425
3.C.7 - Rice cultivation		83.119			2,327.337
4 - Waste	79.623	119.311	5.260	-	4,814.291
4.A - Solid Waste Disposal		48.682			1,363.106
4.B - Biological Treatment of Solid Waste		0.320	0.018		13.843
4.C - Incineration and Open Burning of Waste	79.623	1.590	0.024		130.390
4.D - Wastewater Treatment and Discharge		68.718	5.218		3,306.952

4.5 Trends in Greenhouse gas emissions

Figure 9 shows the growth of GHG emissions in Nepal from 1994 to 2022. Since 2011, emissions have grown at an average annual rate of 3.26%, when compared to the Third National Communication (MoFE, 2017), with recalculations indicating a slightly higher rate of 4.2% per year. The energy sector remains the largest contributor, with rising emissions driven by economic growth, population expansion, and increased access to modern fuels like LPG, which reduces reliance on biomass. However, biomass combustion continues to contribute significantly to CH_4 emissions. The Industrial Processes and Product Use (IPPU) sector has seen the fastest growth, driven by industrial expansion, such as cement production, and improved data availability. The Agriculture, Forestry, and Other Land Use (AFOLU) sector shows mixed trends, with higher emission removals due to better land use and forest management policies, but livestock and agriculture remain key sources of CH_4 and N_2O. The waste sector also has increasing emissions, with growing population, urbanization and industrialization. Overall, the energy sector dominates emissions, highlighting the need for mitigation strategies focused on renewable energy, while IPPU and waste sectors require targeted interventions.

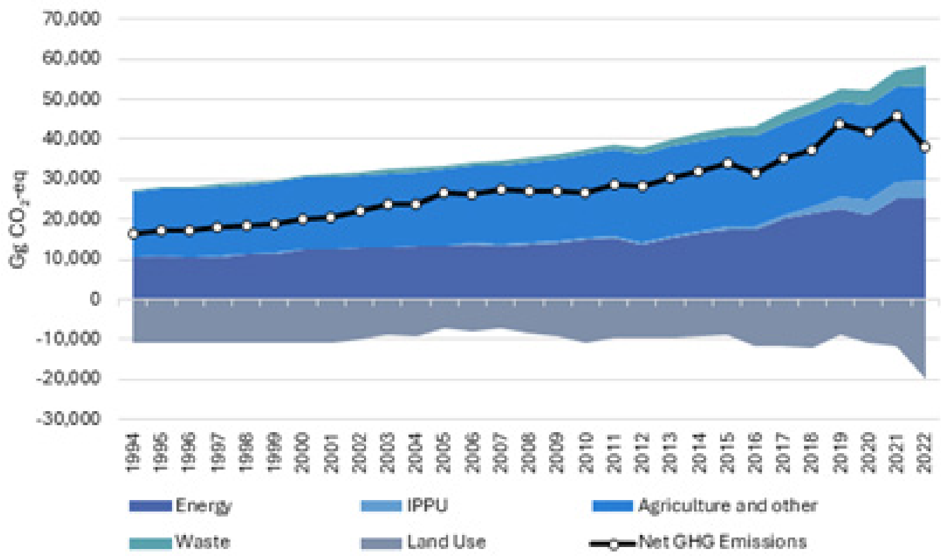


Figure 62: GHG emissions trend by sectors in Nepal from 1994 to 2022

Figure 10 below shows the trend of Nepal's GHG emissions from 1994 to 2022, broken down by CO_2, CH_4, N_2O emissions, and CO2 removals from land use. CO_2 emissions, primarily from

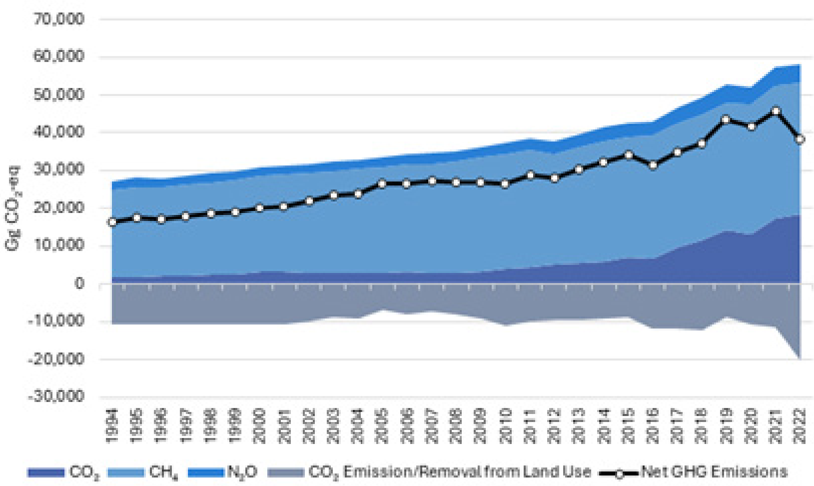


Figure 63: GHG emissions trend by gases in Nepal from 1994 to 2022

energy and industrial sectors, have steadily increased due to rising fossil fuel combustion. CH_4 emissions, the largest contributor, are mainly from agriculture, livestock, rice cultivation, and biomass combustion. N_2O emissions have also grown due to increased fertilizer use in agriculture. CO_2 removals from land use have significantly increased, reflecting successful forest conservation and reforestation efforts. While net GHG emissions have risen, especially after 2011 due to industrialization and energy consumption, carbon sequestration from land use has helped moderate the growth. This underscores the importance of land use management as a carbon sink and highlights the need for mitigation strategies to address rising CO_2 and CH_4 emissions from the energy and agriculture sectors.

4.6 Projections on GHG emissions and removals

Emission projections were conducted using LEAP (Low Emissions Analysis Platform) software, which integrates energy and non-energy sectors. The analysis combined trend and scenario-based methods, using historical data and external parameters. Total GHG emissions, excluding LULUCF, are projected to grow at 2.6% annually, reaching 118,225 Gg CO_2-eq by 2050. Including LULUCF, emissions in 2050 are expected to be 98,243 Gg CO_2-eq, due to the forest land's high sequestration capacity. The IPPU sector is growing the fastest in emissions, while livestock emissions are increasing more slowly. This suggests that industrialization will likely have a larger impact on total emissions, while a shift away from agriculture may lower emissions. However, it is important to consider the social costs and benefits of each sector to ensure effective mitigation without harming the country's economy and well-being.

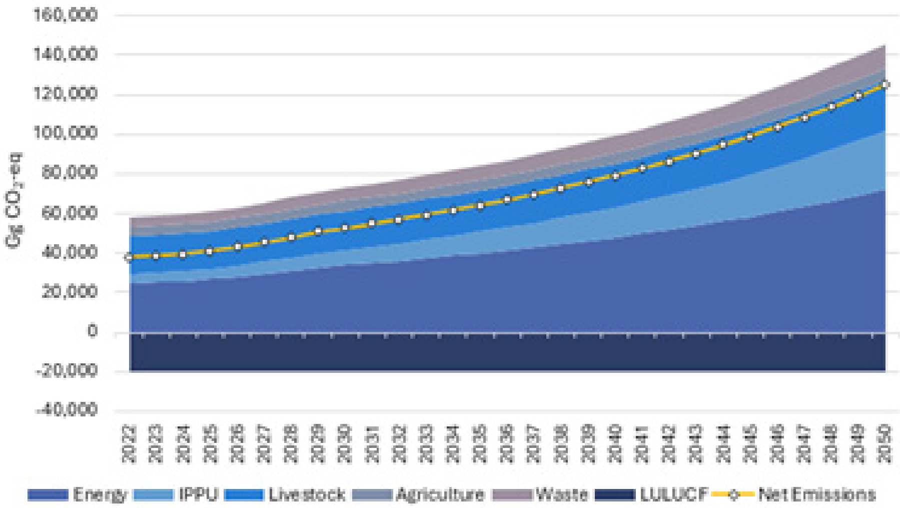


Figure 64: Emission Projection of all sectors till 2050

Mountain range seen from Kalinchowk, Dolakha *Photo by:* **Pradeep Bhattarai**

5 Information Related to Climate Change Impacts and Adaptation Under Article 7 of the Paris Agreement

5.1 Climate Impacts, Risks, and Vulnerabilities

5.1.1 Climate Trend

A climate trend analysis conducted by the Department of Hydrology and Meteorology (DHM) in 2017 indicates that Nepal's annual maximum temperature is rising at a rate of 0.056°C per year, while the minimum temperature is increasing at a much slower and statistically insignificant rate of 0.002°C per year (between 1971 and 2014). Notably, the minimum temperature is declining in some mountainous districts, whereas it is rising in the central Tarai region of Province Two and across the Middle Mountain region from east to west. The increase in maximum temperature is more pronounced in mountainous districts across the country, while it remains relatively lower in the Tarai.

In contrast, Nepal's average annual precipitation declined by approximately 1.3 mm per year over the period from 1971 to 2014. However, projections by the Ministry of Forests and Environment (MoFE) and the International Centre for Integrated Mountain Development (ICIMOD) suggest that average annual precipitation will increase in both the medium term (2030) and the long term (2050). Specifically, precipitation is expected to rise by 2–6% in the medium term (2016–2045) and by 8–12% in the long term (2036–2065). Average temperatures are also projected to increase by 0.92–1.07°C in the medium term and 1.30–1.82°C in the long term.

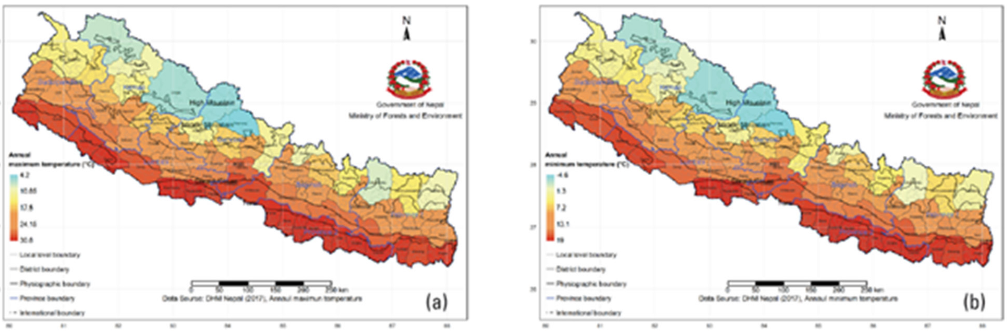


Figure 65: Annual temperature trend; (a) maximum temperature (b) minimum temperature

The post-monsoon season is projected to experience the highest temperature increases by 1.3–1.4°C in the medium term and 1.8–2.4°C in the long term followed by winter, with increases of 1.0–1.2°C and 1.5–2.0°C, respectively. Seasonal precipitation is expected to rise in all seasons except the pre-monsoon, which could see a decline of 4–5% in the medium term. The post-monsoon season may witness the largest increase in precipitation, with a projected rise of 6–19% in the medium term and 19–20% in the long term. These significant shifts in temperature and precipitation patterns are likely to adversely impact food production, water resource management, and overall livelihoods across the country.

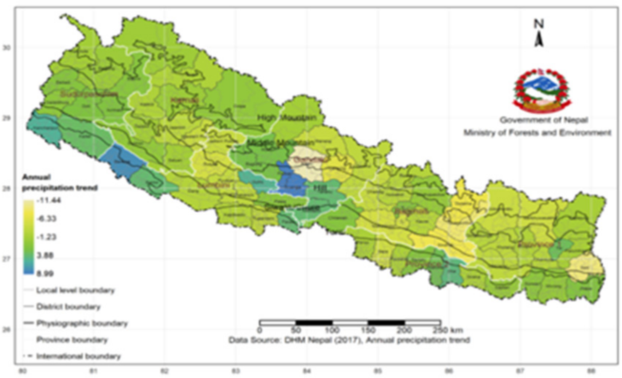


Figure 66: Annual precipitation trend

5.1.2 Climate Change Scenarios

Nepal's climate change vulnerability and risk assessment report (MoFE, 2021) considers two representative climate change trajectories: RCP 4.5 and RCP 8.5. These were selected to reflect medium-term (2016–2045) and long-term (2036–2065) scenarios, corresponding to the 2030s and 2050s, as aligned with the National Adaptation Plan (NAP) process. The baseline reference period is 1981–2010. The subsequent sections detail changes in various climate variables and extreme climate events, analyzed by administrative units and physiographic regions.

Overall, the findings indicate that both temperature and precipitation are expected to increase in the future compared to the reference period. While temperature is projected to rise consistently throughout the century, precipitation changes are expected to be more variable across seasons.

Temperature Scenarios

Under the RCP 4.5 scenario, the medium-term (2030s) average annual temperature is projected to rise by 0.92°C, ranging from 0.77°C to 1.09°C. In the long term (2050s), the average increase is expected to be 1.3°C, with a range of 1.1°C to 1.53°. Under the more extreme RCP 8.5 scenario, the pattern of temperature change remains broadly similar, but with greater intensity. In the medium term, the national average annual temperature increase is projected at 1.02°C, ranging from 0.96°C to 1.24°C. In the long term, the national average increase reaches 1.82°C.

Precipitation Scenarios

In the RCP 4.5 medium-term scenario, average annual precipitation is projected to increase by 2.1%. This increase rises to 7.9% in the long term. Spatial variability is significant, ranging from a decrease of 0.32% to an increase of 5.51%. However, in the long term, precipitation is projected to rise across the entire country. Under the RCP 8.5 scenario, precipitation is projected to increase by 6.4% in the medium term and by 12.1% in the long term.

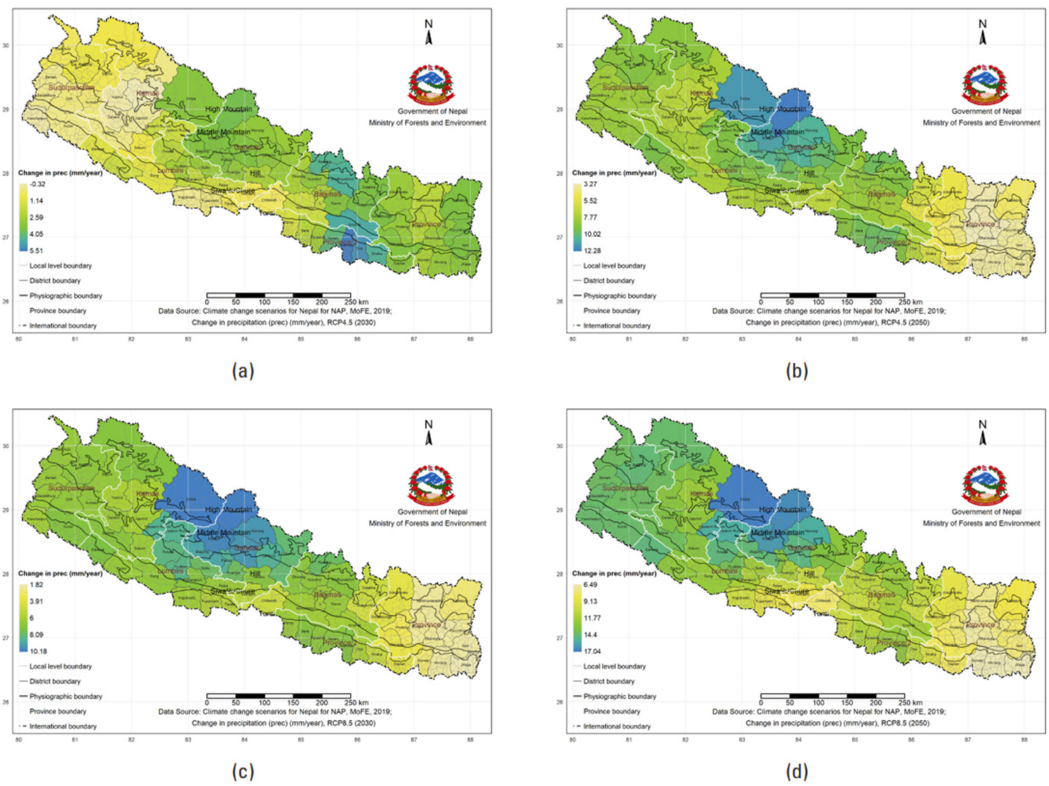


Figure 67: Mid-term and long-term precipitation scenario in RCP 4.5 and 8.5

Projection of Extreme Indices

Warm extremes (warm days, warm nights, and warm spell duration) are expected to increase, while cold extremes (cold days, cold nights, and cold spell duration) are projected to decrease. The greatest increase is expected in warm nights, rising by 30.5 to 37.8 days in the medium term and 43.3 to 59.6 days in the long term. Table 47 outlines the projected changes of the Multi-Model Ensemble in extreme temperature indices.

Table 47: Projected Range of Mean Change in Extreme Temperature Indices (Days)

Indices	**Reference Period (1981–2010)**	**Medium Term (2016–2045)**		**Long Term (2036–2065)**	
	Days	**RCP4.5**	**RCP8.5**	**RCP4.5**	**RCP8.5**
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	17.6	19.3	27.6	26.2	43
Cold Days	15.3	-10.5	-11.2	-19.3	-27.5
Cold Nights	15.3	-12.2	-12.7	-19.7	-27.3
Cold Spell Duration	4.7	-1.3	-1.4	-12.9	-14.8

Source: MoFE (2019)

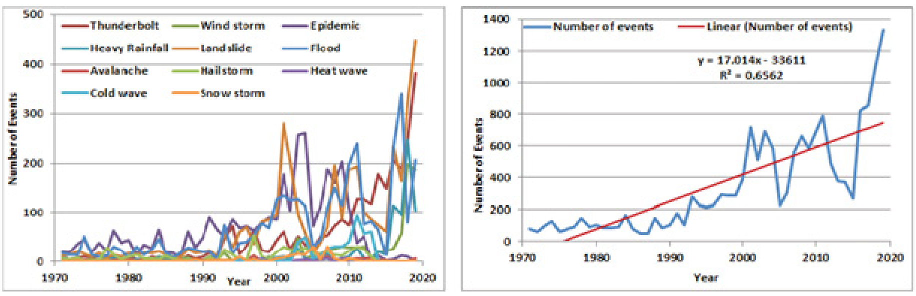
Very wet and extremely wet days are projected to increase in the future compared to the reference period, based on multi-model mean changes in extreme precipitation indices (Table 48). Rainy days are projected to decrease, with a greater reduction under the RCP4.5 scenario compared to RCP8.5. The changes in dry spells (CDD) and wet spells (CWD) show opposite trends in the two RCP scenarios.

Table 48: Projected Range of Mean Changes in Extreme Precipitation Indices (Days)

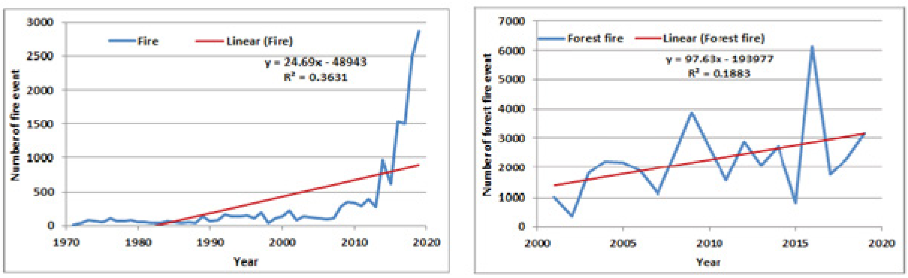
Indices	Mean Annual Days in Reference Period (1981–2010)	Medium-Term (2016–2045)		Long-Term (2036–2065)	
	Days	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Very Wet Days	18.1	0.3	2.2	2.2	3.4
Extremely Wet Days	3.5	0.9	1.0	1.4	2.1
Rainy Days	166.4	-3	-1.6	-1.7	-0.8
CDD (Consecutive Dry Days)	45.3	2.7	-0.7	1.1	-1.3
CWD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

Source: MoFE (2019)

5.1.3 Trend of Climate-induced Hazards



a) Trend of 11 climatic hazards and the impact



b) Trend of fire and forest fire events

Figure 68: Trends of climatic hazards in Nepal- a) Trend of 11 hazards, b) Trend of fire and forest fire

Climatic hazards in Nepal are increasing in frequency and severity, particularly floods, epidemics, and fire events, likely driven by climate change and socio-environmental factors. Nepal mostly faces eleven types of limatic hazards viz: Thunderbolt, Windstorm, Epidemic, Heavy Rainfall, Landslide, Flood, Avalanche, Hailstorm, Heatwave, Coldwave, and Snowstorm.

The 50-year trend of climate-induced hazards and their impacts, fire and forest fire events are analyzed in figure 65 (a and b). Since the 2000s, there has been a sharp increase in hazard events, particularly floods, epidemics, and thunderstorms, reflecting the influence of climatic and socio-economic factors. In contrast, hazards like snowstorms and avalanches have maintained relatively stable frequencies over time. Forest fires have shown a rising trend, with notable spikes in specific years, indicating an increasing frequency and impacted area. Drought events, however, display fluctuating patterns with significant variability but no definitive upward or downward trend. For the uncertainties four models for RCP4.5 and RCP8.5 were used for the climate scenarios for the medium-term and the long-term periods. The Climate change scenarios for Nepal for National Adaptation Plan (NAP) (MoFE, 2019) suggest the higher value of the coefficient of variation in precipitation than in temperature.

5.1.4 Future Scenarios of Climatic Hazards

The NAP report has highlighted that the future climate change is expected to lead to more extreme climate events (precipitation and temperature) by 2045 and 2065. The Climatic Hazards are expected to rise in frequency and severity (Table 49). The Climatic hazard trend analysis shows an increasing frequency of heavy rainfall events, which heightens the likelihood of more frequent and severe flooding and landslides in the future. This trend significantly increases the vulnerability of low-lying districts. Similarly, the observed trend of fluctuating rainfall patterns and prolonged dry spells indicates heightened risks of water scarcity in the future. This can have severe implications for agriculture. The rising temperature trend and erratic rainfall patterns may lead to the increased in forest fires. These severities of the impacts are likely to experienced high/very by most of the districts of Koshi province, Madesh province, Bagmati province and Gandaki province by 2030. Tarai districts and districts of Province two are expected to experience increased extreme events, and the eastern districts of Province one will experience a very high incidence of extreme events.

Table 49: Descriptive scenarios of climatic hazards under future climate change

Climate Hazards	Impact	Medium-term Scenario	Long-term Scenario
Heat waves	Increase	Likely	Very likely
Cold waves	Decrease	Likely	Very likely
Heavy rainfall	Increase	Likely	Very likely
Snowstorms	Decrease	Likely	Likely
Thunderbolts	Increase	Likely	Likely
Windstorms	Increase	Likely	Likely
Hailstorms	Increase	About as likely as not	About as likely as not
Floods	Increase	Likely	Likely
Landslides	Increase	Likely	Likely
GLOFs (Glacial Lake Outburst Floods)	Increase	Likely	Likely
Droughts	Increase	About as likely as not	About as likely as not
Forest fires	Increase	Likely	Likely
Fires	Increase	Likely	Likely
Avalanches	Increase	Likely	Likely
Epidemics	Increase	Likely	Likely

Note: Virtually certain 99-100% probability, very likely 90-100 %, likely 66-100%, about as likely as not 33-66%, unlikely 0-33% and very unlikely 0-10%, exceptionally unlikely (0-1%). Adopted from: NAP1

The climate hazards will interact with and cause harm to vulnerable systems, leading to climate risks that are expected to impact critical systems and human well-being In Nepal, including natural ecosystems, food production, livelihoods, human health, communities and settlements, and infrastructure. By 2050, under the most pessimistic warming scenario, these combined climate impacts are projected to reduce Nepal's economy by 7% compared to baseline projections.

5.1.5 Impacts of Climate Change

Between 1971 and 2019, climate-induced disasters in Nepal caused an annual average of 647 deaths and significant economic losses averaging NPR 2,778 million per year, or 0.08% of the GDP. Major disasters include floods, landslides, epidemics, and fires, with floods affecting the highest proportion of the population and fires causing the greatest economic damage. Extreme rainfall from September 27–29, 2024, caused severe floods and landslides across Nepal, killing 236 people and damaging key infrastructure. Major rivers exceeded danger levels, with Kathmandu recording record-breaking rainfall. Over 17,000 people were rescued, but roads, bridges, hydropower plants, schools, health facilities, agriculture, and telecom sectors suffered heavy losses, totaling over NPR 14 billion in damages (NDR, 2024) Agriculture, which sustains most livelihoods, faces severe threats, with 90% of crop losses linked to erratic weather patterns. Drought alone accounted for nearly 39% of agricultural losses. Climate change is projected to reduce yields of key crops like rice and wheat, especially in the Tarai and Hills, while rising temperatures negatively impact livestock and fisheries. Similarly, Nepal's forests, biodiversity, and watersheds are undergoing shifts in species distribution and phenology, with increased threats from invasive species and habitat degradation. Tourism, water resources, energy, and public health are also highly vulnerable to climate extremes and variability.

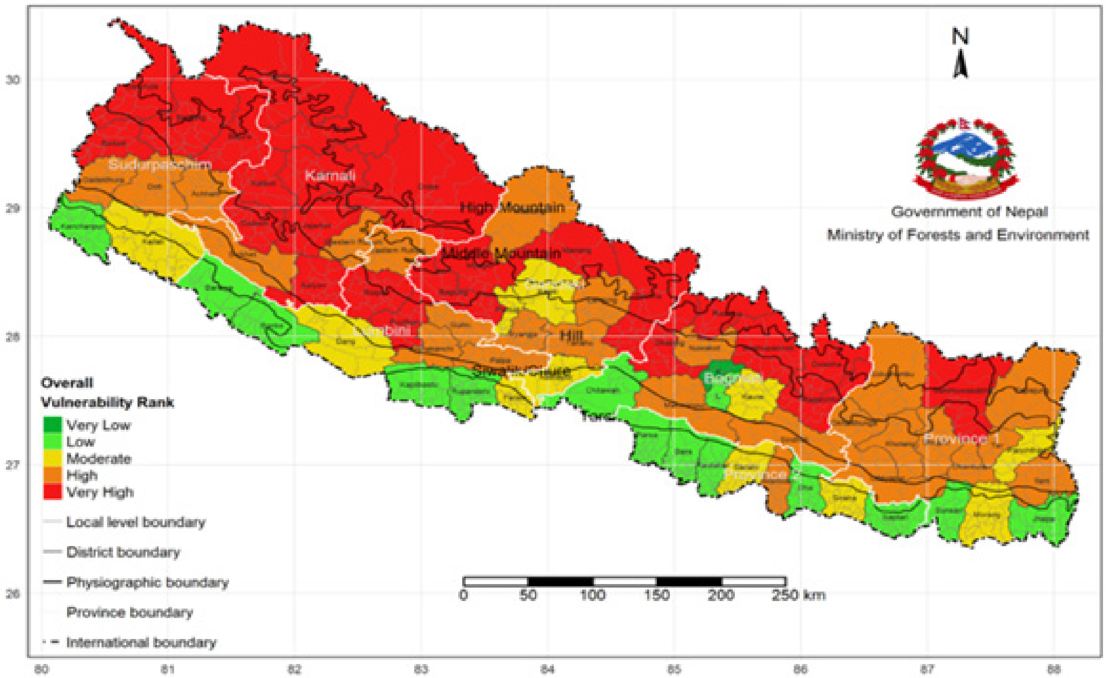


Figure 69: Vulnerability map of Nepal

Rural and urban settlements face heightened risks from floods, landslides, and extreme weather, worsened by unplanned urbanization and inadequate infrastructure. Damage to industry, transportation, and physical infrastructure from events like landslides and cloudbursts disrupts national connectivity and economic stability. Water sources, especially springs in mid-hills, are declining, affecting drinking water access. Climate-related diseases are on the rise, with large segments of the population at risk from malaria, diarrheal diseases, and respiratory illnesses. Vulnerabilities are intensified by socio-economic inequalities, with women, Indigenous Peoples, and marginalized communities disproportionately affected due to limited access to resources and decision-making. Cumulative evidence suggests that climate change will continue to exacerbate both economic and non-economic losses unless comprehensive adaptation strategies are implemented.

5.1.6 Climate Change Vulnerability and Risk

Vulnerability in Nepal is defined as the gap between sensitivity to climate impacts and the capacity to cope and adapt. The Vulnerability and Risk Assessment and Identifying Adaptation Options report (MoFE, 2021) suggests that the risk of climate-related impacts results from the interaction of climate-related hazards (including climate extreme events) with the exposure and vulnerability of human and natural systems. Based on the findings of the report 50 out of 77 districts are highly to very highly vulnerable to climate change, especially in mountainous regions and all mid-hill. Factors such as remoteness, lack of infrastructure, limited resource access, and multidimensional poverty increase vulnerability, while improved roads, access to energy, and biodiversity can help reduce it.

Risk, defined as a function of exposure, vulnerability, and hazards, is also increasing. Districts exposed to floods, landslides, fires, windstorms, and hailstorms already face very high climate-induced disaster impacts. Under climate scenarios (RCP 4.5 and RCP 8.5) projected for 2030, 15–19 districts are classified as very high-risk and 17 as high-risk. Most districts across the Tarai, mid-hills, and mountain regions are expected to fall into high to very high-risk categories in the near future.

5.2 Adaptation Priorities and Challenges

Adaptation to the adverse effects of climate change is a priority for Nepal. Over the last decade, the Government of Nepal has taken several concrete steps to ensure that our development pathway is resilient to climate change and inclusive of the most vulnerable people, households, and communities. NAP has shaped priority programs across eight thematic and four cross-cutting sectors, as highlighted in the National Climate Change Policy 2019. The priorities are based on vulnerability assessments, climate impact studies, geographical and ecological considerations, stakeholder consultations, and alignment with the national and international framework (MoFE, 2021).

Agriculture and Food Security: Nepal emphasizes the development of adaptive technologies, crop varieties, and livestock breeds to ensure food security amidst changing climate conditions. Efforts include establishing efficient irrigation and water management systems, promoting climate-resilient agricultural practices, and strengthening climate information services such as early warning and sectoral information systems. Improvements in grain storage, distribution systems, financial services, and insurance schemes are also prioritized. Furthermore, enhancing farmers' networks and institutions is key to fostering a collaborative and resilient agricultural framework.

Forest, Biodiversity and Watershed Conservation: Nepal's forestry sector plays a pivotal role in climate adaptation, with policies and strategies emphasizing local and landscape-level actions to build climate resilience. The National Forest Policy and the National Agroforestry Policy recognize the forestry sector as an important component of adaptation, and efforts are made to make forests, biodiversity, wildlife, watersheds, and ecosystems resilient to climate change. Attempts to address climate change in forestry include setting clear objectives for managing forests under changing conditions, increasing community education and awareness about adaptation, and assessing the vulnerability of forest ecosystems and communities. Adaptive measures focus on cost-effective strategies to reduce vulnerability, enhance ecosystem recovery, and monitor forests to prevent critical thresholds. These practices aim to mitigate climate change impacts, accelerate recovery, and strengthen resilience, ensuring the sustainability of Nepal's forest resources amidst ongoing environmental challenges.

Water Resources and Energy: This sector involves analyzing climate trends and future scenarios for water resources and energy. Vulnerability assessments identify and evaluate adaptation options, which are integrated into policies and plans. Strategies are developed to implement these measures effectively, ensuring sustainable water and energy resource management in the face of climate variability.

Rural and Urban Settlements: Adaptation priorities for settlements and infrastructure involve developing early warning systems for risks like floods, landslides, and GLOFs. Land-use planning and bylaws are enforced to prevent construction in high-risk areas, while climate-resilient design guidelines for critical infrastructure are implemented. Emergency planning, physical protection measures, relocation of at-risk communities, and establishing insurance mechanisms are critical steps toward safeguarding urban settlements.

Industry, Transport and Physical Infrastructures: Increased climate-induced hazards and extreme weather events significantly elevate the risk of damage to industries and physical infrastructure, thereby disrupting industrial operations. These events also cause disturbances in transport services, which impact the supply of materials, ultimately affecting industrial production. Furthermore, such disruptions can lead to a loss of employment due to interruptions in industrial and transport operations. Additionally, there may be a reduction in the availability of raw materials, further exacerbating challenges faced by industries and transport systems (MoPE, 2017).

Tourism, Natural and Cultural Heritage: Nepal's tourism sector, a crucial contributor to GDP and employment, is highly vulnerable to climate change due to its reliance on seasonal and environmental conditions. Rising temperatures, extreme weather events, and long-term climatic shifts threaten trekking routes, mountaineering, and scenic beauty, affecting livelihoods, economic stability, and the safety of tourists and local communities.

Health, Drinking Water and Sanitation: Capacity building among professionals, government institutions, and stakeholders is essential for adapting public health systems to climate risks. Physical systems and infrastructure are being improved to withstand climate impacts, while services and institutions are strengthened to manage health risks effectively. Research and development on climate change and health will help in establishing databases to track impacts and adaptation measures. Efforts prioritize reaching vulnerable populations and fostering cross-sector collaboration to enhance adaptation strategies (MoPE, 2017).

Disaster Risk Reduction and Management: Nepal is exposed to many natural and human-induced hazards that are impacted by climate change. The impact of climate-induced disasters is felt at the household level through food insecurity, damage to property, and increased prices of food and fuel. The DRRM Act (2017) addresses disaster risk management with a comprehensive approach, focusing on the different stages of the disaster management cycle from preparedness to mitigation, response, and rehabilitation. The Prioritized actions align with the DRRM Act to mitigate the impacts of climate-related disasters felt at the household, community, and National levels.

Gender Equality and Social Inclusion (GESI), Livelihoods and Governance: Nepal is advancing gender equality, social inclusion, livelihoods, and governance as a cross-cutting strategy to enhance climate resilience. Gender-inclusive agricultural technologies, equitable resource access, and structural changes in social norms aim to empower women and marginalized groups. Livelihood diversification, climate education, financial incentives, and alternative industries support vulnerable populations in adapting to climate impacts.

A total of 64 priority programs are identified in the Nepal NAP. The total budget of Nepal's NAP implementation is USD 47.4 billion to implement the priority program until 2050. Nepal will contribute USD 1.5 billion, and external support totaling USD 45.9 billion is required to implement the NAP to 2050. The government requires USD 2.1 billion per year for the delivery of adaptation services through the implementation of the NAP for the medium term.

5.3 Challenges, Gaps, and Barriers to Adaptation

Nepal has demonstrated a strong commitment to tackling climate change through ambitious action plans, policies, and frameworks. However, the nation faces significant challenges that hinder effective implementation. One of the major barriers is the lack of adequate financial resources, which limits the ability to scale up climate adaptation and mitigation efforts. Additionally, gaps in technical expertise make it difficult to design and execute advanced climate-resilient solutions. Furthermore, coordination challenges among various institutions and stakeholders lead to inefficiencies and fragmented efforts. Addressing these issues is essential for Nepal to fully achieve its climate goals and build resilience against future climate impacts (WBG, 2022). Key challenges, gaps, and barriers in relation to adaptation in Nepal are summarized in Table 50.

Table 50: Major Adaptation Challenges, Gaps, and Barriers

Opportunities for Improvement	Areas Needing Strengthening	Opportunities for Capacity Enhancement	Pathways to Enable Action
Financing for Adaptation	Increased focus on mobilizing and scaling up financial resources for adaptation efforts across all vulnerable sectors.	Potential to enhance domestic funding mechanisms and attract international climate finance through innovative approaches.	Building technical skills and institutional frameworks to effectively access and utilize international finance.
Enhanced Climate Data and Projections	Growing recognition of the need for more localized climate data to improve decision-making, especially in agriculture, water, and biodiversity.	Opportunity to develop technical and infrastructural capacity for reliable data collection, analysis, and dissemination.	Investment in localized data systems and knowledge-sharing platforms can close information gaps.
Strengthening Institutional Systems	Momentum exists to bolster institutional capacity for adaptation planning and implementation at all levels.	Room to improve coordination across agencies and invest in technical and human resource development.	Expanding decentralization and empowering local governance can enhance effective program delivery.
Inclusive Adaptation Planning	Greater awareness of the need to empower marginalized groups, including women, indigenous peoples, and Dalits, in climate responses.	Opportunities to translate inclusive policies into action through targeted programs and representation.	Promoting social equity and inclusive participation can ensure that adaptation benefits are widely shared.
Advancing Climate-Resilient Infrastructure and Technology	Increasing demand for modern infrastructure and climate-smart technologies in rural and urban settings.	Potential to scale up access to affordable, sustainable technologies tailored for smallholder farmers and communities.	Strategic investments can improve infrastructure and make technologies more accessible and cost-effective.
Policy Implementation and Enforcement	Nepal has laid strong policy foundations for climate action; now focus is shifting toward effective implementation and enforcement.	Enhancing alignment between national and local plans offers a clear path to strengthening outcomes.	Capacity-building for local governments can help ensure compliance and long-term policy impact.
Cross-Sectoral Synergies	Recognition is growing that collaborative, integrated approaches across sectors enhance climate resilience.	Opportunities to establish platforms for coordination and joint planning between sectors like agriculture, water, and health.	Strengthening intersectoral mechanisms will lead to more holistic and efficient adaptation strategies.

Source: World Bank (2022), MoFE 2021, MoALD 2019

5.4 Climate Change Adaptation Policies, plans, and strategies

Nepal has developed several policies, plans, and strategies to accelerate climate change adaptation efforts on the ground. The Constitution of 2015 underscores the principles of equality, prosperity, and social justice, while the Long-term vision envisions a pollution-free environment, biodiversity conservation, and enhanced climate resilience. These efforts are further guided by the 16th Periodic Plan and the National Adaptation Plan (NAP) 2021–2050, which prioritize nature-based solutions, climate-smart infrastructure, and integrated planning. Additionally, the Local Adaptation Plan of Action (LAPA) 2019 and the National Climate Change Policy 2019 provide a strong foundation for promoting localized adaptation measures and mobilizing climate finance.

Table 51: Major Adaptation Policies, Plans, and Strategies in Nepal

Policy/Strategy/Plan	Key Adaptation Measures
National Adaptation Plan (NAP) 2021–2050	• Community-Based Adaptation (CBA): Enhancing the resilience of vulnerable communities through local-level interventions. • Climate-Resilient Agriculture: Promoting drought-tolerant crop varieties and sustainable water management. • Disaster Risk Reduction: Implementing early warning systems for floods and landslides; strengthening community-level preparedness.
Framework for Local Adaptation Plans of Action (LAPA) 2019	• Resilient Infrastructure: Constructing flood-resistant housing and infrastructure in high-risk areas. • Water Resource Management: Promoting rainwater harvesting and improved irrigation systems. • Climate-Resilient Agriculture: Supporting adaptive agricultural practices to ensure food security. • Disaster Preparedness: Reducing community vulnerability to floods, landslides, and extreme weather. • Social Protection & Inclusion: Safeguarding women, children, the elderly, and marginalized groups from climate impacts.
Disaster Risk Reduction and Management Act (2017)	• Early Warning Systems: Expanding systems for climate-induced hazards like floods and landslides. • Community Preparedness: Conducting training programs on emergency response and disaster preparedness.
National Framework for Climate Resilient Agriculture (2018)	• Climate-Smart Agriculture (CSA): Encouraging low-emission and climate-resilient technologies. • Agroforestry & Soil Conservation: Promoting practices that improve soil health and moisture retention.
National Biodiversity Strategy and Action Plan (NBSAP) 2014–2020	• Sustainable Forest Management: Supporting reforestation and carbon sequestration efforts. • Ecosystem-Based Adaptation (EbA): Restoring wetlands, forests, and grasslands to mitigate climate impacts.
Second Nationally Determined Contributions (NDC) – 2020	• Sectoral Integration: Embedding adaptation in national plans across energy, transport, and infrastructure. • Monitoring & Evaluation: Establishing systems to assess adaptation progress and impact.

Water Resources Strategy (2002) & National Water Plan (2005)	• Glacier and Snow Melt Monitoring: Developing systems to forecast water-related hazards. • Integrated Water Resource Management (IWRM): Promoting sustainable use in agriculture and hydropower.
Climate Change and Health Adaptation Strategies (2017)	• Urban Health Plans: Reducing heat-related mortality through targeted health interventions. • Vector Control: Strengthening disease control programs for climate-sensitive illnesses like malaria and dengue.
National Climate Change Policy (2019)	• Climate Finance: Accessing the Green Climate Fund (GCF) and the Adaptation Fund for local projects. • Institutional Capacity Building: Empowering local governments to plan and implement adaptation measures.

5.5 Science, gender perspectives, and traditional knowledge related to adaptation

Nepal's adaptation policies are designed by a blend of scientific research, gender-sensitive approaches, and indigenous knowledge, creating an adaptation framework that is inclusive, evidence-based, and culturally relevant. These principles are embedded in key national policies such as the National Adaptation Plan (NAP), the Local Adaptation Plans of Action (LAPA), and the Climate Change Gender Action Plan, ensuring that adaptation efforts are both effective and equitable, as summarized in Table 16.

Table 52: Science, Gender, and Knowledge related adaptation

Key adaptation Aspects	**Key features for Adaptation**
Science-Based Adaptation	**Climate Data and Modelling:** The government utilizes climate models and meteorological data to predict changes in temperature, precipitation patterns, and glacier melt. Scientific institutions like the Department of Hydrology and Meteorology (DHM) provide vital data for developing sectoral adaptation plans **Vulnerability and Risk Assessments:** Regular assessments are conducted to identify areas most vulnerable to climate impacts, enabling the government to prioritize actions in regions facing high risks of floods, landslides, and droughts. **Technology-Driven Solutions:** Adaptation programs include the promotion of climate-smart technologies in agriculture, such as the use of drought-resistant crop varieties, efficient irrigation systems, and solar-powered water pumps.
Gender Perspectives (DA/ADB, 2022)	**Women's Participation:** Including women in climate discussions and actions addresses their unique roles in households and agriculture, leading to more comprehensive and inclusive solutions. **Empowering Leadership:** Gender-targeted programs ensure women's active participation, with initiatives achieving at least 33% female representation and including women in leadership roles. **Economic and Social Benefits:** Improved water supply and increased farm income for women and marginalized groups enhance broader community aspects like health, sanitation, and nutrition. **Social Harmony Through Participation:** Participatory planning processes foster collaboration, leading to better social cohesion and inclusive decision-making.

Indigenous and Local Knowledge and Practices (ILKP) (MoSTE, 2015)	**Local Water Management:** Indigenous water practices, such as farmer-managed irrigation systems, highlight the importance of local knowledge in ensuring sustainability and equitable resource use. Challenges like unplanned urbanization necessitate blending traditional methods with modern technologies to maintain water conservation and supply. **Forest and Pasture Management:** Community-based forestry practices rooted in cultural norms and secure resource access enhance climate resilience. Integrating traditional methods with contemporary policies and ensuring social equity promote sustainable forest and pasture management. **Rural Transport Infrastructure:** Traditional bridges and trails exemplify cost-effective, resilient infrastructure. Government policies should incorporate local knowledge to improve and sustain these systems, fostering adaptation and disaster risk reduction. **Settlements and Housing:** Indigenous communities on fragile lands require resilience-building initiatives focusing on safety, resource access, and low-carbon solutions. Integrating local knowledge with modern construction practices enhances adaptive capacity. **Traditional Social Institutions:** Local institutions play a pivotal role in preserving natural resources and driving collective action. Strengthening and integrating these with formal frameworks can improve sustainability and climate adaptation efforts. Women's contributions to resource management should also be scaled and replicated for broader impact.

5.6 Initiatives taken to promote Nature-based Solutions and Ecosystem-Based Adaptation

Nepal's national and local policies increasingly recognize the importance of Nature-Based Solutions (NbS) in enhancing climate adaptation. These approaches focus on the sustainable management of natural resources, ecosystem conservation, and community-based initiatives that deliver co-benefits for both biodiversity and livelihoods. Key policy initiatives supporting NbS include the National Climate Change Policy (2019), the National Biodiversity Strategy and Action Plan (2014–2020), the Forest Policy (2019), the Disaster Risk Reduction and Management Act (2017), the LAPA Framework (2019), and the Local Disaster and Climate Resilience Planning (LDCRP) Guidelines (2017). Together, these policies promote NbS as a vital adaptation strategy at both national and local levels.

Ecosystem-based Adaptation (EbA) plays a crucial role in supporting sustainable development across various sectors in Nepal. By leveraging ecosystem services, EbA enhances resilience in agriculture, forestry, energy, water, health, education, and livelihoods, thereby contributing directly to the achievement of the United Nations Sustainable Development Goals (SDGs) by 2030.

EbA supports sustainable natural resource management and improves agricultural productivity through services such as water regulation and soil conservation. It also contributes to economic development while enhancing social cohesion by reducing resource-related conflicts, especially in climate-vulnerable areas. One of its most significant strengths is its ability to improve the resilience of vulnerable communities, enabling them to better withstand extreme climate events such as floods and landslides. This aligns with the Sendai Framework for Disaster Risk Reduction, which advocates for integrating climate adaptation into disaster risk management.

Recognizing the value of EbA, the Government of Nepal has embedded both community-based and ecosystem-based approaches into national policies to support long-term environmental sustainability and resilient livelihoods. Notably, Nepal's Second Nationally Determined Contribution (NDC) emphasizes sustainable resource management and circular economy principles—core tenets of EbA. Similarly, the National Adaptation Plan (NAP) 2021–2050 includes several programs aligned with ecosystem-based strategies.

Nature-based Solutions and Ecosystem-Based Adaptation-related Initiatives in Nepal:

Ecosystem-Based Adaptation (EbA) in Mountain Ecosystems (2011-2016): The EbA project has significantly contributed to watershed management, forest conservation, and rangeland restoration in the Panchase area of western Nepal. It focuses on building climate-resilient livelihoods by promoting sustainable agriculture and agroforestry practices. This initiative is part of a broader effort to integrate ecosystem restoration with climate change adaptation in Nepal's mountain ecosystems.

Hariyo Ban Program (Phase I-2011-2016 & Phase II- 2016-2021): The Hariyo Ban Program has played a vital role in forest restoration, watershed management, biodiversity conservation, and climate adaptation through community-driven interventions. The program operates in critical biodiversity hotspots like the Chitwan-Annapurna Landscape and the Tarai Arc Landscape. It emphasizes local involvement in forest protection and climate resilience, ensuring long-term sustainability in forested regions.

Sustainable Land Management in the Churia Range (2013-2016): In the Churia Range, efforts have focused on reforestation, controlled grazing, agroforestry, and the construction of water-harvesting structures. These measures aim to reduce soil erosion and improve local water management, which is essential for the region's agricultural productivity and overall ecosystem health. The project has contributed to mitigating the negative effects of land degradation in the area.

Building Climate Resilience of Watersheds in Mountain Eco-Regions (2014-2019): This project focuses on the restoration of degraded watersheds and the implementation of soil and water conservation measures. Additionally, it promotes the construction of water harvesting systems to improve water availability for local communities. The goal is to enhance the resilience of both ecosystems and communities, ensuring sustainable water resources in Nepal's mountainous regions.

Nepal Climate Change Support Programme (NCCSP, Phase I 2013-2019 and Phase II 2019-2024): The NCCSP integrates climate adaptation and resilience into local government planning, with a strong focus on improving governance and empowering marginalized groups, especially women and socially disadvantaged communities. The program fosters the inclusion of climate change adaptation into national policies and ensures that the most vulnerable communities' benefit from climate resilience initiatives.

Ecosystem-Based Adaptation (EbA) II in Mountain Ecosystems (2019-2025): EbA II aims to improve water retention, reduce soil erosion, and enhance the resilience of local ecosystems and communities, building on the success of the first phase.

Adaptation for Small-Holders in Hilly Areas (ASHA, 2015-2021): This project aimed to make self-reliant communities, organizations, and local authorities reduce the vulnerability of local communities to climate-related risks and strengthen an enabling institutional environment for climate change adaptation. The sub-watershed approach of the project envisions integrated adaptation planning to achieve the multiple objectives of conservation, sustainable natural resource management, and reducing the adverse impacts of climate change.

Developing Climate Resilient Livelihoods (2020–2024): This project focused on safeguarding vulnerable communities and their assets from climate change-induced disasters by applying a long-term, multi-hazard approach, with a particular stewardship role for women and marginalized communities. The project also aims to address the functional integrity of the pilot watershed through capturing the policy, institutional knowledge gaps, adoption of new tools and techniques, and interventions of multiple activities at the pilot scale. The project is being implemented at the pilot scale in the Lower Dudhkoshi watershed, a major tributary of the Sunkoshi sub-basin, located in the eastern part of Nepal.

Improving Climate Resilience of Vulnerable Communities and Ecosystems in the Gandaki River Basin (2020-2026): This project Is focused on enhancing the climate resilience of vulnerable communities and ecosystems in the 19 districts of GRB since 2022, with the aim of supporting livelihoods in facing the challenges of climate change for many households in the Gandaki River Basin of Nepal. The major activities focus on community resilience, ecosystem resilience, and climate governance.

Building a Resilient Churia Region in Nepal (BRCRN, 2019-2027): This project has envisaged scaling up climate-resilient Sustainable Natural Resource Management (SNRM); strengthening institutions and planning for climate-resilient SNRM and improving knowledge, awareness, and local capacity for climate-resilient SNRM.

5.7 Progress on the implementation of adaptation

5.7.1 Progress on the adaptation strategy

Nepal's formulation of the National Adaptation Plan (NAP) 2021–2050 reflects a proactive commitment to addressing the impacts of climate change. As envisioned by the National Climate Change Policy 2019, Nepal's target is to formulate a gender-responsive local adaptation plan (LAPA) in all 753 local government units. So far, Nepal has formulated 263 LAPAs in the local government. The implementation of the NAP is scheduled for review in 2031. In the lead-up to this, Nepal has initiated numerous adaptation-focused projects and programs across various sectors, supported by both bilateral and multilateral partners, as well as national funding. These efforts underscore the country's dedication to building resilience, reducing vulnerability, and aligning with national policies and international commitments under the Paris Agreement. Notable progress has been achieved through the development and implementation of sectoral strategies that support both climate change mitigation and adaptation.

Table 53: Adaptation Progress in Nepal till 2024

Agriculture and Food Security	
Envisioned Actions	**Progress**
Capacity Building of Agricultural Institutions	• Significant dependency on informal knowledge and traditional practices. • Training programs are provided to farmers through Agriculture Knowledge Centers (AKCs), but Limited capacity-building efforts at the local level.
Strengthening Climate Services and Agriculture Information Systems	• Agricultural extension services have been restructured, but coverage remains limited.
Integrated Soil and Nutrient Management	• Organic matter content in soils ranges from 1-2.5% in Tarai to 2.5-5% in mid-hills, indicating variable progress.
Climate-Resilient Water Management Systems	• 58% of cultivated land is irrigated; federal programs aim to expand resilient irrigation systems.
Conservation and Development of Genetic Resources	• High dependency on staple crops (rice, wheat, maize); limited evidence of diversification to conserve indigenous varieties. • Emphasis on promoting indigenous crops under Food and Nutrition Security Programs (FANSEP) • The national gene bank has preservation of 11,389 accessions. • Annually, about 1,000 accessions are collected, and community-based conservation has been expanded in 31 districts. • Some 65 accessions of 16 wild relatives of crops have been conserved in situ and ex-situ.
Sustainable Agriculture and Food Security Programs	• The improved annual production of rice is 5.7M MT, a 4.3% increase from the previous year. Maize (2.9M MT) and wheat (2M MT), though food deficits persist. • Food Secured Household reached 48.2% (variation exists (NSO, 2024) • FANSEP reached 656,245 beneficiaries (92% women); yields improved by over 100% across major crops.
Development of Risk-Sharing Models (Insurance)	• Since 2020, both cost and production-based insurance have been implemented, covering livestock and agriculture confined to 14 types of risk. • Weather-based insurance in Nepal is in a pilot phase, limited to certain districts only.

Promotion of Climate-Smart Collective Agriculture	• Formation of Farmer Groups for cooperative farming, but challenges in scaling climate-smart practices
Improving Food and Nutrition Security	• Stunting reduced to 25%, underweight prevalence to 19%, and wasting to 8% A total of 31,932 metric tons of food grain is in stock in the National Food Security Warehouse and the SAARC Food Bank

Source: ADS, 2024/NPC, 2019

Forest, Biodiversity, and Watershed Conservation	
Envisioned Actions	**Progress**
Conservation of the Forest ecosystem	• Nepal's forest cover has reached 46.08% of the total land area, with significant improvements in forest management through community forestry.11
Watershed Management and Restorations	• Key initiatives in watershed management have been carried out to conserve biodiversity and improve water security. • Wetlands cover 5.5% of Nepal's land, with 10 internationally recognized Ramsar sites • A total of 690 watershed areas have been identified • A total of 16,050.69 hectares of degraded land have been rehabilitated, contributing to both soil conservation and biodiversity enhancement. • About 4,645.35 hectares of land have been reclaimed and protected through bioengineering methods in river and stream bank areas, particularly in the Chure and Bhavar regions.
Restoration of Degraded Forest and Wetlands	• Implementation of scientific forest management practices, including restoration projects for degraded forests, enhancing watershed health. • Seed stands established for 38 socially and economically important tree species
Protection of Biodiversity Hotspots	• Establishment of protected areas, covering 23.39% of Nepal's land, including critical biodiversity hotspots like the Tarai Arc Landscape. • Establishment of conservation breeding centers for species like vultures, crocodiles, and elephants • Establishment of botanical and zoological gardens as platforms for education, awareness, and recreation. • Tiger population increased by 63% (from 2009 to 2013) to 198; rhino population increased by 15% (from 2011 to 2015) to 645.
Enhancement of Local and Community Participation in Conservation	• Over 20,000 community forest user groups engage in forest management, ensuring local involvement in biodiversity conservation and watershed protection. • Allocation of 30-50% of annual revenue from protected areas to local communities for biodiversity conservation and development. • More than 88% of the country's area has come under the landscape-level conservation.

Promotion of Ecosystem-Based Adaptation (EbA)	• Ecosystem-based adaptation projects include forest restoration and watershed management to reduce vulnerability to climate impacts, improving resilience. • 3,000 CFUG adopted climate change planning.
Monitoring and Data Collection for Biodiversity and Forest Health	• Regular biodiversity monitoring programs include species censuses and forest resource assessments, enhancing forest and watershed management. • A dedicated Biodiversity Monitoring Protocol for REDD+ has been developed to track biodiversity changes in regions like the Tarai Arc Landscape. • Use of SMART patrolling and MIST (Management Information System Tool) for wildlife surveillance. • Application of geospatial tools for forest resource assessments, aiding in mapping biodiversity-rich areas
Sustainable Livelihood Programs in Forest-dependent Communities	• Programs like non-timber forest products (NTFPs) and agroforestry contribute to sustainable livelihoods while promoting forest biodiversity. • 5,221 hectares of land have been conserved through on-farm activities aimed at improving soil and water conservation.

Source: MoFE, 2018

Water Resources and Energy	
Envisioned Actions	**Progress**
Promoting Climate-informed Decision Making	• 88 real-time hydro-meteorological stations established nationwide (2023). 66 meteorological stations for real-time monitoring • 21% of districts access climate data for local water management. • WECS expanded energy consumption and supply surveys across all 7 provinces for informed planning.
Developing Climate-Smart Design for Water Resource Infrastructure	• 30% of water infrastructure projects are integrated with IWRM principles.
Reducing GLOF Risks in Key River Basins	• 21 glacial lakes identified as dangerous in the Gandaki, Koshi, and Karnali Basins
Promoting Renewable Energy in Rural Areas	• Installed 40250 kW micro hydro power, 794276 household solar systems, 450770 household biogas, 11104 improved water mills, 1423242 efficient mud cook stoves, 3097 KWP solar-wind mini-grid projects, 4332 institutional solar systems, 2464 solar dryers and cookers, 3691 solar drinking water and irrigation pumps.14
Enhancing Resilience of Hydropower Projects	• 2538.27 MW installed hydropower capacity, with an additional 5809.63 MW under construction • 5 hydropower projects retrofitted for resilience. • Total installed capacity at risk from GLOFs: 1,200 MW.

Improving Energy Mix for Sustainability	• Fuel wood accounted for 62% of total energy usage in 2019, agricultural residue and animal manure constituted 3.1% and 3.2%, respectively, while petroleum products made up 15.4%. Coal consumption accounted for 6.9%, LPG for 3.3%, and electricity for 3.9% of total energy use, and the renewable sources accounted for 2.1% of the total energy mix15. Hydropower constitutes 94% of the electricity supply, and solar and wind contribute only 4.6%.
Climate-Resilient Flood Control	• 66 flood warning systems operational across major river basins. • Embankments covering 1,000 km were built for flood management in 2018.
Clean and Efficient Energy Technology Development	• Installed 59,385 electric cook stoves, 18293 kWp solar rooftop. • 6,213 electric vehicles in operation, supported by 58 charging stations.
Access to Water and Energy Information Systems	• 70% of municipalities have access to integrated water-energy data systems.

Source: MoWERI, 2018

Tourism, Cultural and Natural Heritage	
Envisioned Actions	**Progress**
Promoting Eco-Friendly Tourism Practices	• Six Protected Areas (PAs) selected for sustainable tourism initiatives in 2020. • Increased trekking and mountaineering activities with 154,262 participants in 2023, a 150% rise from 2022.
Conserving Climate-Sensitive Cultural Heritage Sites	• Guidelines developed to protect archeological and cultural sites, focusing on areas like Muktinath Temple and Lo-Manthang • 18,531 visitors to Pashupatinath and 85,232 to Lumbini, highlighting a need for climate-resilient infrastructure in these areas in 2023.
Enhancing Resilience of Tourism Infrastructure	• Expansion of tourism infrastructure includes new airports in Pokhara and Lumbini. • 182 star-rated hotels (up from 173 in 2022) and 1,416 non-star hotels were established in 2023.

Health, Drinking Water and Sanitation	
Envisioned Actions	**Progress**
Strengthening Climate-Resilient Healthcare Facilities	• Limited progress on climate-resilient healthcare retrofitting; focus remains on basic facility improvements • The Health Sector National Adaptation Plan (NAP) for Climate Change 2023-2030 aims to build a climate-resilient health system by minimizing health risks through coordinated efforts across all government levels and stakeholders.
Improving Access to Safe Drinking Water	• 98% of the population has access to at least basic drinking water services till 2022. • Only 25% use treated drinking water (boiling, filtering), urban areas perform better than rural regions in ensuring treated water.

Promoting Sustainable Sanitation Practices	• 73% of the population has access to basic sanitation facilities. • Open defecation reduced to 7% in 2022. Urban households are better connected to sewer systems (11%) than rural households (0.2%) .
Enhancing Early Warning Systems for Health Risks	• Limited availability of early warning systems for climate-sensitive health risks, though reporting systems for disease outbreaks exist.
Building Capacity for Health Workers on Climate-Related Diseases	• Training for health workers on climate-sensitive diseases remains minimal; the focus is on primary healthcare delivery.
Implementing Community-Based Water Management Systems	• Community-based water management systems are limited; rural areas heavily depend on communal water sources .
Promoting Hygiene Education and Awareness Campaigns	• Hygiene promotion achieved 72% access to basic handwashing facilities in 2022. • 61% of women reported washing and changing in privacy with appropriate materials during their last menstruation.
Expanding Water Quality Monitoring Systems	• Monitoring water quality is minimal
Improving Resilience of Water Supply Infrastructure	• 88% of households has sufficient water availability. • Mountain zones have only 76% in 2022.
Strengthening Policy Framework for Health and Sanitation	• Development of Climate change Health adaptation strategy 2023 .

Source: MoHP, 2022/H-NAP, 2023

Disaster Risk Reduction and Management	
Envisioned Actions	**Progress**
Understanding Disaster Risk	• Development of the Bipad Portal: A disaster management information system consolidating hazard, risk, and vulnerability data. • Deployment of advanced tools like VizRisk for risk mapping and socio-economic assessments. • Expansion of National Risk Communication Strategy in 2024. • Establishment of NDRRMA and decentralized DRRM governance.
Strengthening DRR Governance	• Establishment of NDRRMA and decentralized DRRM governance. • Adoption of key policies: DRRM Act (2017), Strategic Plan (2018–2030), and the Local Disaster and Climate Resilience Framework (LDCRF). • Strengthened coordination across federal, provincial, and local levels .
Investing in DRR for Resilience	• Mandated 5% of the development budget for DRR activities. • Accessed $112.1M from the Green Climate Fund. • Piloted index-based insurance schemes and incentivized private sector investments. • Updated building codes for seismic and flood-resilient infrastructure.

Enhancing Preparedness and Recovery	• Shifted to a Multi-Hazard Early Warning System (MHEWS) • Established smart sirens in 49 flood-prone areas. • Launched platforms like Volunteer Management System (VMS) and Godam for resource and volunteer mobilization. • Owner-driven post-disaster reconstruction programs. • The 16th Plan indicates that 263 LAPAs are prepared.

Source: MoHA, 2024

Envisioned Actions	Progress
Promoting Women's Leadership in Climate Adaptation	• Women's participation in decision-making remains progressive, as women account for 33% of forest user group memberships, but less than 10% in leadership positions.
Enhancing Social Inclusion in Adaptation Efforts	• GESI integrated into 8 sectoral ministries .
Building Climate-Resilient Livelihoods	• 92% of rural women rely on climate-sensitive agriculture. • Adaptive practices like community seed banks have limited outreach
Strengthening Governance for Climate Adaptation	• Climate Change Policy (2019) integrates GESI at the provincial and local levels. • 45% of municipalities have GESI frameworks incorporated into local adaptation plans.
Developing Capacity-Building Programs for Vulnerable Groups	• Lack of robust training programs addressing climate impacts on marginalized groups. Focus remains on primary adaptation. • Over 2,000 women and marginalized individuals trained under provincial climate programs.
Ensuring Gender-Responsive Climate Financing	• Gender-Responsive Budgeting (GRB) has been implemented in all sectoral ministries since 2007. • No integration at provincial/local levels.

Other Development Sector:	
Envisioned Actions	**Progress**
Promoting Climate-Resilient Urban Housing and Infrastructure	• National Urban Development Strategy (2017) envisions a resilient, balanced urban system with a 15-year plan covering infrastructure, environment, finance, economy, land, and governance. Piloting eco-friendly housing projects in urban areas under various donor-supported programs. • Safe housing increased to 54% in 2022, surpassing the 43.9% target. The population in slums dropped to 200,000, surpassing the 325,000 target.

Encouraging Green Urban Development and Land Use Planning	• Development of green spaces under urban planning projects like Smart City initiatives. • Integration of environmental and social safeguards in urban expansion projects. • Progress in formulating land-use plans emphasizing green zones. • Land-use planning frameworks implemented in 60% of municipalities.
Improving Waste Management Systems in Urban and Rural Areas	• Initiatives like waste segregation and recycling programs in municipalities. • Improved solid waste management in urban centers through public-private partnerships. • Expansion of biogas plants to process organic waste in rural areas. • Urban waste management systems improved: 60% of municipalities have introduced waste segregation and recycling systems. • Rural waste management coverage: 40% of rural households have access to improved waste management services.
Strengthening Climate-Informed Local Governance	• Climate-resilient planning frameworks adopted by municipalities. • Integration of climate adaptation into local government annual plans. • Increased community engagement in climate action through local adaptation plans (LAPA). • 65% of municipalities have prepared Local Adaptation Plans of Action (LAPA).
Expanding Early Warning Systems for Disaster Management	• Operational early warning systems for floods, landslides, and glacial lake outbursts. • Community-based disaster preparedness programs implemented in vulnerable areas. • Collaboration with neighboring countries for regional disaster forecasting.
Promoting Climate-Resilient Industrial Zones	• Nepal has identified climate-resilient industrial zones under its Green, Resilient, and Inclusive Development (GRID) framework
Encouraging Low-Emission Transport Systems	• Electric vehicles increased from 1,500 in 2019 to 6,000 in 2023.
Promoting Efficient Water and Waste Management in Industries	• Industrial zones have introduced wastewater treatment systems, with coverage expanding to over 25% of major industrial areas in 2022. • Solid waste segregation programs have been introduced in 50 industrial areas to promote recycling
Strengthening Policy Framework for Climate-Resilient Infrastructure	• National Urban Development Strategy (2017) and Land Use Policy (2015) emphasize resilient housing, green urban spaces, and disaster preparedness. Similarly, National Urban Policy 2007, Habitat III National Report 2016, and Sustainable Development Goals: Status and Roadmap 2016-2030.

5.7.2 Monitoring and evaluation of adaptation actions and processes

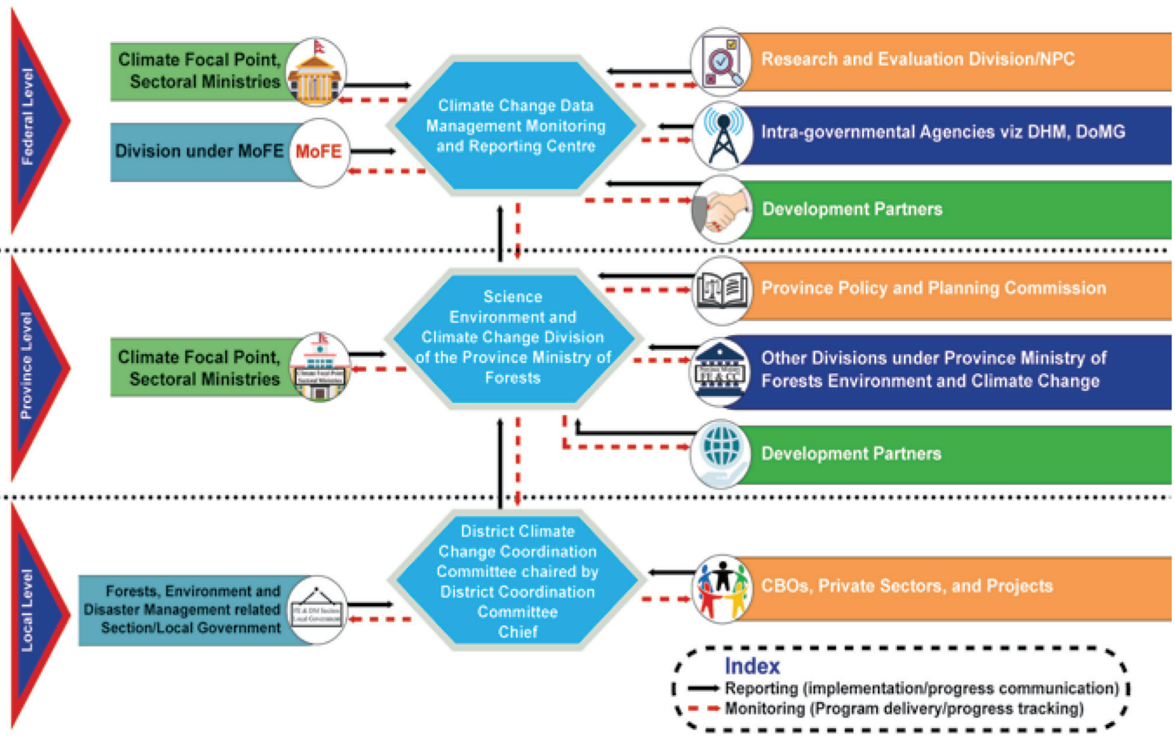
In the absence of a national monitoring and evaluation (M&E) framework for climate adaptation, tracking and assessment currently take place only at the project and program level. Nevertheless, efforts are underway to mainstream climate change adaptation into Nepal's existing national M&E system. The National Planning Commission (NPC) conducts periodic reviews of government expenditures, while for externally funded initiatives, monitoring is carried out by the respective funding agencies and implementing partners.

Although a climate budget code has been introduced for planning purposes, there is still no established mechanism for tracking climate-related expenditures or evaluating the effectiveness of adaptation measures. As the national focal point for climate change, the Ministry of Forests and Environment (MoFE) is responsible for reviewing and reporting on the implementation of the National Adaptation Plan (NAP). While a comprehensive national M&E system for climate adaptation has not yet been institutionalized, the NAP provides a foundational approach for monitoring progress. Since Nepal is currently implementing the Capacity Building Initiative for Transparency (CBIT) with support from GEF, Nepal's National Measurement, Reporting and Verification (MRV) sectoral and National framework is in progress.

Federal Level: A climate change data management, monitoring, and reporting center is proposed at the federal level. This center will monitor the activities of the Science, Environment, and Climate Change Division of provincial ministries, development partners, intergovernmental federal agencies, MoFE divisions, climate focal points within federal sectoral ministries, and the Research and Evaluation Division of the NPC. These institutions are expected to report their implementation progress to the federal center.

Provincial Level: At the provincial level, the Science, Environment, and Climate Change Division of the respective provincial ministry will be responsible for overseeing and tracking the implementation of climate adaptation programs. This division will monitor activities conducted by development partners, climate focal points of sectoral provincial ministries, other divisions within the provincial climate change focal ministry, and the Province Policy and Planning Commission. These agencies will regularly report their progress to the division.

Local Level: At the local level, the District Climate Change Coordination Committee—chaired by the head of the District Coordination Committee—is responsible for tracking and compiling reports on climate adaptation initiatives. Community-based organizations, the private sector, program partners, and the forest, environment, and disaster management sections of local governments report their activities to this committee, which oversees and monitors local adaptation efforts.



(Source; Adopted from NAP 2021-2050)

Figure 70: MRV framework for Nepal's NAP process

5.8 Information related to averting, minimizing, and addressing loss and damage associated with climate change impacts

5.8.1 Observed impacts of climate-induced disasters in Nepal

From extreme heatwaves, cold waves, drought, GLOF, floods, landslides, and thunderstorms, Nepal is already facing severe climate change impacts, causing widespread 'loss and damage' with tragic implications for affected communities in Nepal. The devastating impacts of the climate crisis are most dramatically and tragically demonstrated by the recent extreme climate events that took the lives and livelihoods of all three regions: mountain, hill, and plain land (Tarai).

Disasters significantly hinder Nepal's development progress and create long-term vulnerabilities, costing the country millions of dollars annually. For example, following the devastating 2015 earthquake, Nepal's Gross Domestic Product (GDP) growth rate dropped from 6% in 2014 to 2% in 2015, and further declined to just 0.4% in 2016. Similarly, during the fiscal year 2019/20, the GDP growth rate fell to -2.12% due to the impacts of the COVID-19 pandemic (MOHA, 2022).

In extreme years, such as during the 2017 Tarai floods, a single disaster event caused economic losses equivalent to approximately 2.08% of the GDP (based on 2017/18 figures at current prices). In 2020, landslides caused an estimated USD 12 million in damages in Raskot Municipality of Kalikot District. Likewise, record-breaking rainfall in Manang District during the 2021 monsoon, the highest monthly and annual average in two decades, resulted in damages worth an estimated USD 9.5 million (MoFE, 2021). More recently, floods and landslides triggered by heavy rainfall between 26 September and 16 October 2024 led to losses exceeding NPR 46 billion (NDRRMA, 2024).

Urban areas tend to experience higher economic losses compared to rural areas, with notable variations across ecological zones. The hill regions, particularly Bagmati Province, have recorded the highest levels of damage. Over the past five years, households across the country have suffered extensive damage to physical infrastructure from climate-induced disasters. Among these, floods were the most prevalent, affecting 50.2% of households, followed by landslides (43.3%) and inundation (36.2%)(CBS, 2022).

Box 3 1. Nationwide Extreme Precipitation Induced Floods and Landslides (September, 2024)

The unprecedented and extreme rainfall between 27-29 September, 2024 caused widespread devastation across Nepal, leading to severe flooding, inundations, and landslides. According to the Department of Hydrology and Meteorology, 77 out of 222 monitoring stations reported heavy rainfall exceeding 200 mm, with water levels in 23 hydrological stations surpassing the danger mark. The Saptakoshi River reached its highest flow in 56 years, and Kathmandu recorded 239.7 mm of rainfall in 24 hours, breaking previous records. The disaster left 236 people dead, 19 missing, and 165 injured. Rescue operations saved over 17,000 people, but damage to infrastructure was immense, particularly in Koshi, Bagmati, and Lumbini Provinces.

A total of 24 road sections are still affected, including major highways like the Mechi Highway, B.P Highway, and Araniko Highway. Similarly, 44 suspension bridges across various rivers and streams in Nepal have sustained varying levels of damage, while 25 bridges are fully damaged and 19 are partially damaged. The estimated total cost of repairs is NPR 1.042 billion.

Hydropower projects also suffered significant damage, with 11 plants with a total installed capacity of 625.96 MW having been affected, and multiple transmission lines were also affected, costing NPR 4.35 billion. According to a preliminary report from the Department of Roads, the combined damage to roads and bridges has resulted in a total loss of NPR 2.5 billion. Similarly, 96 school buildings and 66 health facilities have been damaged across 14 districts. The agriculture and livestock sectors alone reported substantial losses, with over NPR 6 billion in damages to farms and livestock, and it was estimated that the loss in the telecommunications sector was NPR 554 million. (source: NDRRMA, 2024).

5.9 Opportunities in Climate Change Adaptation in Nepal

5.9.1 Water Resources and Energy

Aligning Nepal's national development plans, including sectoral targets, with the Sustainable Development Goals (SDGs) serves the dual purpose of improving quality of life while strengthening climate change adaptation. Promoting renewable energy and energy efficiency, alongside transitioning from petroleum-based vehicles to electric alternatives, presents a critical opportunity. Replacing kerosene, firewood, and petroleum products with energy-efficient cookstoves, biogas, electric cookstoves, and electric heaters can reduce rural household energy expenditures.

Promoting various forms of renewable energy technologies (RETs) for micro-enterprises and income-generating activities can expand local employment opportunities and contribute to rural upliftment. For example, replacing traditional incandescent bulbs with solar-powered and energy-efficient alternatives such as CFLs can result in significant local savings.

Vulnerable groups, including women, children, and low-income households, can improve their socioeconomic conditions by using the saved time for income generation, building social networks, and enhancing knowledge on health. These efforts, as highlighted by A. Suman (2021), contribute significantly to climate adaptation in Nepal. Additionally, using bio-digesters to convert waste into energy and organic fertilizer offers multiple benefits: enhancing crop productivity, encouraging organic farming, promoting climate-resilient crop varieties, and improving soil health.

5.9.2 Forest, Biodiversity, and Watershed Conservation

Nepal's extensive forest and biodiversity resources are vital for ecological stability and human livelihoods, forming a strong base for climate adaptation. Expanding community-based forest management programs can enhance local ownership and build on the success of over 23,000 community forest user groups.

Integrating ecosystem-based adaptation (EbA) approaches into national strategies presents a dual advantage: restoring degraded ecosystems and increasing the resilience of vulnerable communities. Strengthening watershed conservation through multi-stakeholder collaboration can enhance water availability, reduce landslide risks, and improve agricultural productivity. Introducing payment for ecosystem services (PES) schemes can incentivize biodiversity conservation and ensure sustained ecosystem benefits. Research and investment in climate-resilient species and ecosystem restoration are essential to preserve Nepal's ecological heritage.

5.9.3 Agriculture and Food Security

Agriculture, the backbone of Nepal's economy, holds vast potential for climate-smart transformation. Implementing climate-smart agriculture (CSA) practices such as crop diversification, conservation tillage, and agroforestry can reduce climate-related risks. Enhancing access to weather forecasting and climate-resilient seeds empowers farmers to make informed decisions.

Expanding irrigation infrastructure, especially in the mid-hill regions, is critical for boosting productivity and ensuring food security. Promoting sustainable livestock management can strengthen this vital sub-sector's resilience. Strengthening farmer cooperatives and linking them to markets will also mitigate economic uncertainties and improve adaptive capacity.

5.9.4 Disaster Risk Reduction and Management

Nepal's growing frequency of climate-induced disasters highlights the urgency for robust disaster risk reduction and management. Establishing a comprehensive early warning system that incorporates modern technology and local knowledge can save lives and reduce economic losses. Investing in climate-resilient infrastructure, such as flood-resistant housing and landslide prevention systems, is essential.

Developing integrated river basin management plans can mitigate floods and maintain ecosystem services.

Community-based preparedness initiatives and insurance schemes for vulnerable populations can expedite recovery and reduce financial stress post-disasters. Including disaster education in school curricula can foster a culture of resilience from an early age.

5.9.5 Urban and Rural Settlements

Nepal's urban and rural areas face distinct climate vulnerabilities. In urban settings, green infrastructure, such as rooftop gardens, urban forests, and permeable pavements, can combat heat islands and improve water management. Incorporating climate risk into urban planning ensures sustainable urban growth.

In rural areas, promoting climate-resilient housing and integrating adaptation into settlement development are crucial. Expanding clean energy access and improving waste management are shared priorities across both settings. Additionally, planning for climate-resilient migration and new settlements in safer zones can reduce disaster risks for displaced populations.

5.9.6 Industry, Transport, and Physical Infrastructure

To build climate-resilient infrastructure, Nepal must focus on low-carbon development and climate-proof designs. Integrating climate risk assessments in infrastructure projects can lower long-term costs. The use of sustainable construction materials and energy-efficient industrial practices delivers both economic and environmental gains.

In transport, upgrading r oad networks to withstand extreme weather and expanding electric public transit systems will enhance resilience and cut emissions. Climate-resilient cross-border trade infrastructure can support economic growth while protecting critical supply chains. Public-Private Partnerships (PPPs) can be instrumental in financing green infrastructure.

5.9.7 Tourism, Natural and Cultural Heritage

Nepal's tourism sector, closely tied to its natural and cultural assets, can drive adaptation if steered toward sustainability. Promoting eco-tourism and community-based tourism ensures environmental protection and local benefit-sharing. In protected areas, sustainable tourism practices can balance conservation with development. Cultural heritage sites—often vulnerable to natural hazards—require climate-resilient preservation that blends traditional techniques with modern solutions. Investing in diversified tourism infrastructure and year-round tourism activities can offset risks related to seasonal variability. Collaboration between government and private actors is key to fostering innovation in sustainable tourism.

5.9.8 Gender Equality and Social Inclusion

Promoting gender equality and social inclusion is integral to Nepal's climate adaptation agenda. Women, indigenous peoples, and marginalized groups are disproportionately affected by climate change but often lack access to decision-making processes and resources. Developing gender-sensitive adaptation policies and ensuring the participation of women and vulnerable groups in climate planning can lead to equitable and effective solutions. Supporting women-led enterprises and incorporating indigenous knowledge systems strengthens adaptation outcomes. Establishing financial safety nets—such as insurance and microcredit—reduces vulnerability and fosters resilience. Capacity-building programs must prioritize youth, women, and marginalized communities to build inclusive adaptive capacity.

5.9.9 Promoting Innovation and Preventing Maladaptation

Public investments in road infrastructure have improved connectivity, reducing isolation in rural and remote areas. However, several challenges have emerged. Poor design and maintenance have led to increased road-related disasters, making road accidents the leading cause of disaster-related fatalities in Nepal. Furthermore, inadequate planning has disrupted natural drainage systems, drying up critical water sources, and contributing to maladaptation. These issues underscore the urgent need for innovation in infrastructure planning. Climate-resilient, eco-sensitive road development can prevent such unintended consequences and align development with long-term adaptation goals.

5.9.10 Building Climate-Adaptive Business Ecosystems

Nepal has significant potential to develop climate-adaptive business ecosystems that align with its development and environmental priorities. The forest and biodiversity sector, though underutilized, offers opportunities to create sustainable businesses based on timber and non-timber forest products. Integrating agricultural and forest-based economies, such as converting forest biowaste into compost and biochar for degraded lands, can generate mutually beneficial synergies. These strategies not only support national economic development but also strengthen local resilience and contribute to climate adaptation goals.

6 Financial, Technology Development and Transfer, and Capacity Building Support Needed and Received under Articles 9-11 of the Paris Agreement

Under the United Nations Framework Convention on Climate Change (UNFCCC) framework, climate finance is defined as funding, whether local, national, or international, sourced from public, private, or alternative channels, aimed at supporting climate change mitigation and adaptation efforts (UNFCCC, 2021). In line with the convention's principle of "common but differentiated responsibilities and respective capabilities," developed countries are obligated to provide financial assistance to help developing nations meet the convention's goals. The UNFCCC also emphasizes that developed countries should continue to lead in mobilizing climate finance from diverse sources and mechanisms, recognizing the critical role of public funding. This support should align with country-led strategies and address the specific needs and priorities of developing countries.

In Nepal, international financial assistance is channeled through three primary modalities: On Budget, On Treasury (OBOT); On Budget, Off Treasury (OBOfT); and Off Budget, Off Treasury (OfBOfT). The OBOT modality involves funds that are fully integrated into the government's financial system. These funds are recorded in the government's annual budget document, known as the Red Book, and are disbursed and managed through official government channels, ensuring full oversight and accountability. The OBOfT modality also involves budgetary alignment, as donors coordinate with the government and reflect their contributions in the Red Book. However, while the government provides approval and partial oversight, the actual disbursement and utilization of funds remain the responsibility of the donor agencies. The third modality, OfBOfT, is typically used for technical assistance and implementation support projects that are carried out by international non-governmental organizations (INGOs). In this approach, funds do not pass through the government's financial system but are instead managed directly by INGOs and disbursed through local partner organizations or NGOs. These projects are registered with the Social Welfare Council (SWC), the government body responsible for regulating I/NGO operations in Nepal. While government institutions have limited control over project implementation under this modality, the SWC is mandated to authorize, review, and monitor such activities to ensure alignment with national priorities. However, this report records the fund received/secured from GEF, GCF and some bilateral funding supporting to climate action in Nepal.

6.1 Information on Financial Needs, including Support Needed and Received under Articles 9-11 of the Paris Agreement

Nepal has developed the Nationally Determined Contribution (NDC) Implementation Plan (2021–2030) and the National Adaptation Plan (NAP) (2021–2050) to ensure seamless and timely implementation of the NDC and NAP targets. Both plans clearly outline the financial requirements for implementing activities sector-wise and sub-sector-wise (see Figure 70 and Figure 71).

The total estimated cost for implementing the NDC by 2030 is USD 33.04 billion. The financial support required (in billion USD) for implementing the NDC by sector and sub-sector until 2030 is illustrated in Figure 71.

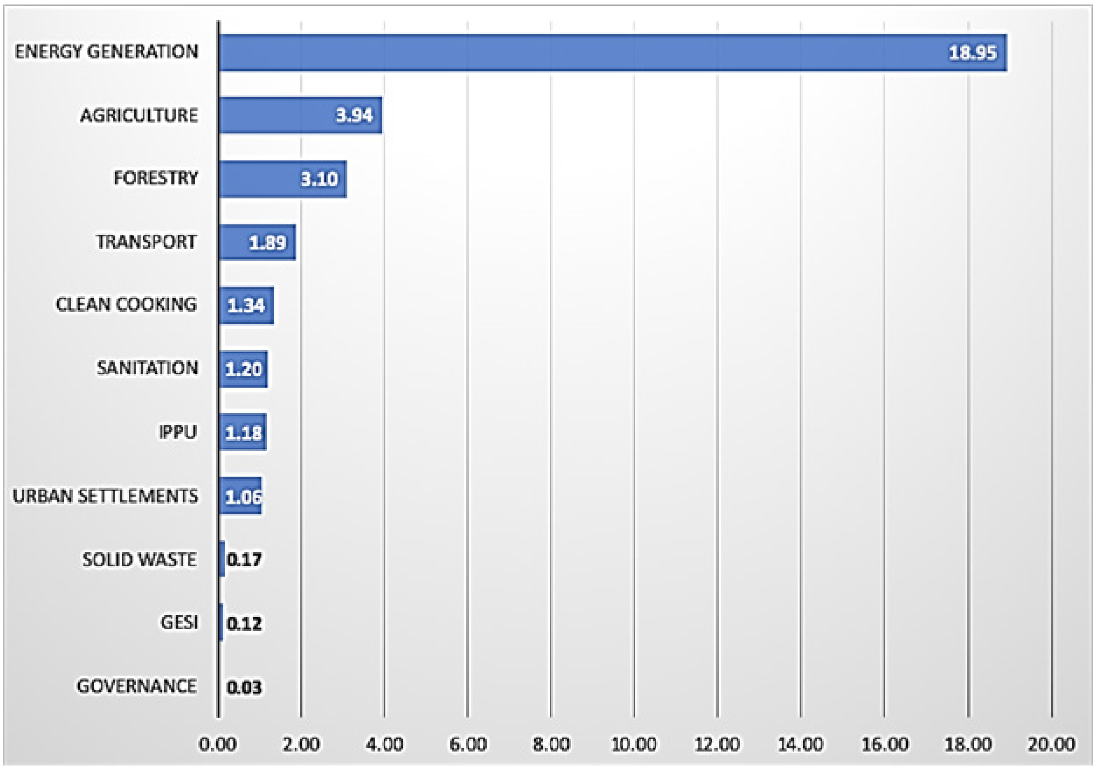


Figure 71: Financial Support Needed Costs for NDC Implementation by Sector/sub-sector till 2030 (in billion USD)

Similarly, the total indicative cost of Nepal's National Adaptation Plan (NAP) is estimated at USD 47.4 billion to implement 64 priority programs by 2050. Of this, Nepal will contribute USD 1.5 billion, while the remaining USD 45.9 billion will be sourced from external funding. To implement the priority actions identified in the NAP, the government requires USD 2.1 billion annually. The financial support needed (in billion USD) for the implementation of the NAP by sector and sub-sector until 2050 is presented in Figure 72.

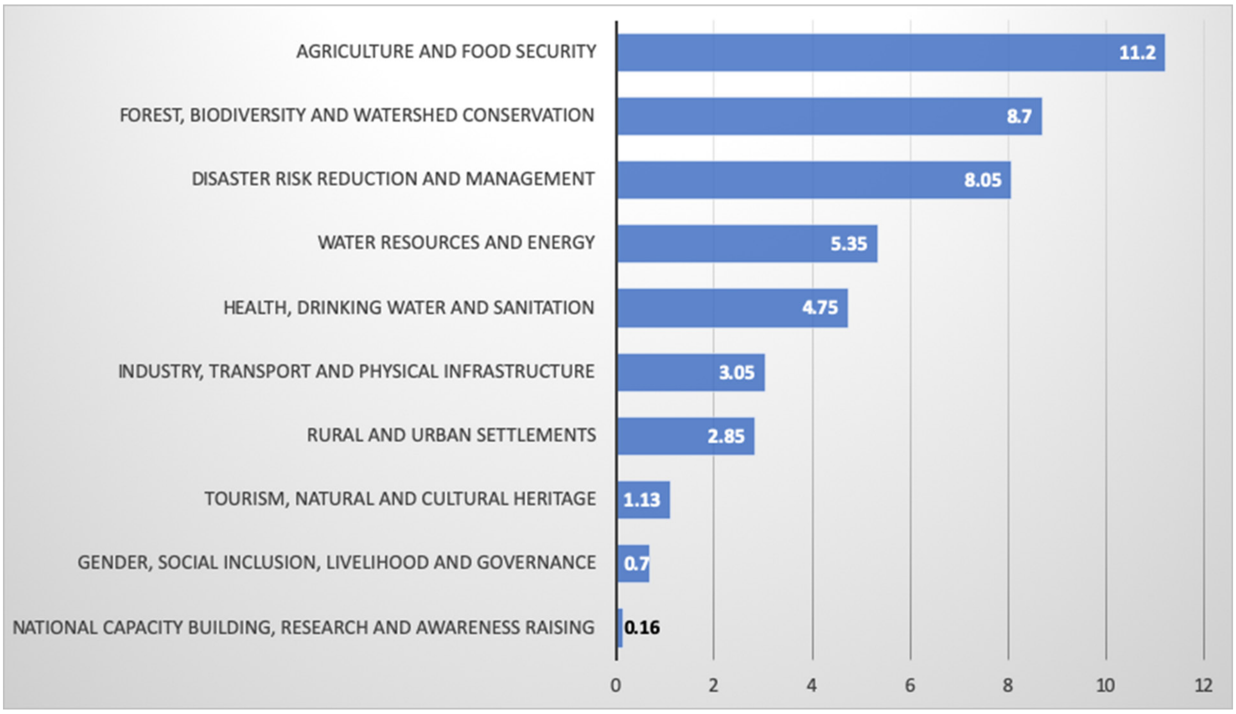


Figure 72: Financial Support Needed Costs for NAP Implementation by Sector/sub-sector till 2050 (in billion USD)

Information on financial support received by developing country parties under Article 9 of the Paris Agreement

S. N	Title of activity, program, project, or other	Channel	Donor	Recipient entity	Implementing entity	Amount received (climate-specific)		Time frame	Financial instrument	Type of support	Sector	Subsector	Contribution to technology development and transfer (0=no, 1=yes)	Contribution to capacity building objectives (0=no, 1=yes)	Status of activity
						Domestic currency (in Million)	USD (in Million)								
1	Adaptation for Smallholders in Hilly Areas (ASHA)	Multilateral	IFAD	MoALD and MoFSC	Department of Agriculture and Department of Forest	1,815.43	17.76	2015-2021	Grant	Adaptation	Agriculture and Water Resources	Food Security	0	1	Completed
2	Adapting to Climate-Induced Threats to Food Production and Food Security in the Karnali Region of Nepal	Multilateral	AF	UN World Food Programme	WFP, MoSTE, MoFALD	257.05	2.34	2018-2022	Grant	Adaptation	Agriculture	Livelihood	0	1	Completed
3	Building a Resilient Churia Region in Nepal (BRCRN)	Multilateral	GCF	FAO	MoFE	4,351.69	39.30	2019-2027	Grant	Cross Cutting	Forest and Land Use	Ecosystem and Ecosystem Services	0	1	Ongoing
4	Building National Capabilities of Nepal to meet requirements of the Enhanced Transparency Framework (ETF) of the Paris Agreement	Multilateral	GEF	WWF-US	MoFE/WWF Nepal	217.25	1.65	2023-2025	Grant	Cross Cutting	Capacity Building on ETF	Capacity Building	0	1	Ongoing
5	Catalyzing Ecosystem Restoration for Climate Resilient Natural Capital and Rural Livelihoods in Degraded Forests and Rangelands of Nepal	Multilateral	GEF/ LDCF	UNEP	MoFE, Ministry of Agriculture and Cooperatives	576.33	5.25	2018-2025	Grant	Adaptation	Forestry	Livelihood	0	1	Completed

6	Community-Based Flood and Glacial Lake Outburst Risk Reduction	Multilateral	GEF-LDCF	UNDP	DHM and the Ministry of Environment and Population	602.28	6.30	2013-2019	Grant	Adaptation	Climate and Disaster Risk Management	Climate and Disaster Risk Management	0	1	Completed
7	Developing Climate Resilient Livelihood in Vulnerable Watershed in Nepal	Multilateral	GEF/LDCF	UNDP	MoFE	775.11	7.00	2020-2024	Grant	Adaptation	Forestry	Soil Conservation and Watershed Management	0	1	Completed
8	Ecosystem-based Adaptation for Climate Resilient Development in the Kathmandu Valley, Nepal	Multilateral	GEF	UNEP	KVDA	691.25	6.24	2019-2026	Grant	Adaptation	Forestry	Ecosystem	0	1	Ongoing
9	Grid Solar Energy Efficiency Project (GSEEP)	Multilateral	IDA	MoEWRI and IUCN	NEA	10,039.06	98.21	2015-2022	Grant	Mitigation	Energy	Renewable Energy	1	1	Completed
10	Improving Climate Resilience of Vulnerable Communities and Ecosystems in the Gandaki River Basin, Nepal	Multilateral	GCF	IUCN	MoFE	3,266.90	27.40	2020-2026	Grant	Adaptation	Forest and Land Use	Ecosystem	0	1	Ongoing
11	Local Climate Adaptive Living Facility (LoCAL)	Multilateral	UNCDF	MoFE	MoFE	382.44	2.86	2024-2030	Grant	Adaptation	Capacity Building	Capacity Building	0	1	Ongoing
12	Managing Watersheds for Enhanced Resilience of Communities to Climate Change in Nepal (MaWRiN)	Multilateral	GEF/LDCF	WWF-US	MoFE /WWF Nepal	1,186.76	9.02	2023-2029	Grant	Adaptation	Forestry	Watersheds	0	1	Ongoing
13	Mitigating GHG Emissions through Modern, Efficient, and Climate-Friendly Clean Cooking Solutions (CCS)	Multilateral	GCF	GCF	AEPC	2,693.01	21.12	2022-2027	Grant	Mitigation	Energy	Clean cooking Solution	0	1	Ongoing

14	Nepal Climate Change Support Programme (NCCSP-I): Building Climate Resilience	Bilateral	UK/ DFID/ EU / Republic of Cyprus	DFID/ UNDP	MOSTE, MoFALD, AEPC, DDC, DCCs	2,817.77	21.28	2013-2019	Grant	Adaptation	Agriculture and Forestry	DRR, GESI	0	1	Completed
15	Nepal Climate Change Support Programme Phase II (NCCSP 2)	Bilateral	UK	MoFE	MoFE and MacDonald, Chemonics	3,387.23	30.59	2019-2024	Grant	Adaptation	Climate Risk	Climate Risk	0	1	Ongoing
16	Nepal Emission Reduction Program in the Tarai Arc Landscape: Carbon Fund	Multilateral	FCPF	WB	MoFE	5,365.35	45.00	2021-2025	Grant	Mitigation	AFOLU	Forest	0	1	Completed
17	Nepal REDD+ Readiness Preparation Support Project	Multilateral	FCPF	WB	REDD IC	539.71	5.20	2017-2022	Grant	Adaptation	AFOLU	Forest	0	1	Completed
18	Pilot Program for Climate Resilience (PPCR): Building Resilience to Climate-Related Hazards (BRCH)	Multilateral	CIF/WB	IBRD	MoEWRI / Department of Hydrology and Meteorology / MoALD	1,914.72	16.00	2013-2020	Grant	Adaptation	Resilience, Disaster Risk Reduction and Climate Change	Resilience, Disaster Risk Reduction and Climate Change	1	1	Completed
19	PPCR: Building Climate Resilience of Watersheds in Mountain Eco-Regions (BCRWME)	Multilateral	CIF/ADB	ADB	Department of Soil Conservation and Watershed Management and MOSTE	1,117.56	11.69	2013-2020	Grant	Adaptation	Water	Watersheds	0	1	Completed
20	Pilot Programme for Climate Resilience (PPCR): Capacity Development for Mainstreaming Climate Change Risk Management in Development (MCCRMD)	Multilateral	ADB	ADB	Ministry of Education, Science and Technology (MoEST)/ MoAD	639.03	7.16	2012-2017	Grant	Adaptation	AFOLU, Water, GESI, Energy	AFOLU, Water, GESI, Energy	0	1	Completed

21	PPCR: Building Climate Resilient Communities through Private Sector Participation (BCRC-PSP)	Multilateral	WB- IFC, CIF	PPCR, WB-IFC, Climate Investment Fund,	DSCWM, MoAD & DHM; MoSTE; MoAD & Private companies; MoFSC, DNPWC & DOF	306.66	3.00	2015-2020	Grant	Adaptation	Capacity Building	Capacity Building	0	1	Completed
22	Preparation of the First Biennial Update Report (BUR) to the UNFCCC-I	Multilateral	GEF	MoFE	UNEP	32.50	0.30	2016-2019	Grant	Adaptation & Mitigation	Preparation of BUR	Preparation of BUR	0	1	Completed
23	Preparation of the First Biennial Update Report (BUR) to the UNFCCC-II	Multilateral	GEF	MoFE	UNEP	38.67	0.35	2018-2020	Grant	Adaptation & Mitigation	Preparation of BUR	Preparation of BUR	0	1	Completed
24	Preparation of the Third National Communication (TNC) to the United Nations Framework Convention on Climate Change (UNFCCC)	Multilateral	GEF	MoFE	UNEP	48.75	0.45	2016-2019	Grant	Adaptation & Mitigation	Preparation of TNC	Preparation of TNC	0	1	Completed
25	REDD+ Implementation	Multilateral	UNEP/ UN-REDD/ FAO	MoFE	MoFE	68.42	0.52	2023-2024	Grant	Mitigation	AFOLU	Forest	0	1	Completed
26	Reducing Vulnerability and Increasing Adaptive Capacity to Respond to Impacts of Climate Change and Variability for Sustainable Livelihoods in Agriculture Sector in Nepal	Multilateral	GEF/ LDCF	FAO	MoALD and MoFSC	274.87	2.69	2015-2020	Grant	Adaptation	AFOLU	Agriculture	0	1	Completed

27	Renewable Energy for Rural Livelihood (RERL)	Multilateral	ADB	UNDP	AEPC	376.48	3.40	2019-2024	Grant	Mitigation	Energy	Renewable Energy	1	1	Completed
28	Restoring the degraded watershed and livelihoods of Lakhandei river basin through Sustainable Land Management	Multilateral	GEF	IUCN	MoFE		1.50	2021-2025	Grant	Adaptation	Land Degradation				ongoing
29	SREP- Supported Extended Biogas Project	Multilateral	CIF	WB	AEPC	932.20	7.90	2014-2021	Grant	Mitigation	Energy	alternative energy	1	1	Completed
30	Strategic Program for Climate Resilience (SPCR); Pilot Program for Climate Change (PPCR)	Multilateral	ADB/ CIF/WB	MoF/MoFE/ MoEST	DoH & MoALD	951.71	8.37	2013	Grant	Adaptation	AFOLU, Water, GESI, Energy, DRR	AFOLU, Water, GESI, Energy, DRR	0	1	Completed
31	Strengthening National Level Institutional and Professional Capacities of Country Parties towards Enhanced UNCCD Monitoring and Reporting	Multilateral	GEF	UNEP, MoFE	UNEP, MoFE	11.57	0.09	2022-2024	Grant	Cross-cutting	Capacity Building for UNCCD Reporting	Capacity Building for UNCCD Reporting	0	1	Completed

6.2 Information on Capacity Building Support Needed by Developing Country Parties Under Article 11 of the Paris Agreement

Despite the clear requirements for transparency in climate action and reporting, Nepal continues to face significant challenges in establishing an effective and transparent Measurement, Reporting, and Verification (MRV) system. Key issues include limited research and insufficient data across GHG-emitting sectors, as well as the unavailability of emission factors for many key sources. Additionally, limited coordination among MRV-related initiatives, inadequate financial resources, and the absence of a harmonized reporting format hinder progress. The country also grapples with limited institutional capacity for centralized data generation, storage, and retrieval, and weak quality assurance mechanisms in the preparation of GHG inventories.

Other pressing barriers include the limited availability of sector-specific technical experts, unclear institutional roles and responsibilities for monitoring and reporting, and low awareness among key data-providing agencies regarding reporting requirements and guidelines. Gaps in data management systems further impact the consistency and reliability of reported information. Moreover, there is limited understanding of the relationship between climate change and observed impacts, such as disaster events, loss of lives, and declines in agricultural productivity. The lack of mechanisms for continuous expert engagement, limited collaboration among government sectors, academia, and civil society, and insufficient technical and financial resources continue to impede the development of a robust MRV system. Furthermore, limited systems exist to report on the use, effectiveness, and outcomes of financial and technical support, which restricts transparency and accountability in climate finance.

Despite these challenges, Nepal is making notable efforts to strengthen its MRV system. The government is actively leveraging existing databases and technical capacities in collaboration with international partners to report on climate action. Efforts are also underway to build a formal institutional mechanism through enhanced coordination among relevant ministries, line agencies, the private sector, and civil society organizations. This includes developing guidelines, protocols, and methodologies for a centralized climate action management system and investing in technical capacity building to meet the reporting and transparency requirements under the Enhanced Transparency Framework (ETF) of the Paris Agreement.

References

- Acharya, K. R. (2019). Nepalese Foreign Trade: Growth, Composition, and Direction. NCC Journal, 4(1), 91–96. https://doi.org/10.3126/nccj.v4i1.24741
- ADB (2017). Mainstreaming Climate Risk Management in Development Progress and Lessons Learned from ADB Experience in the Pilot Program for Climate Resilience (PPCR). Asian Development Bank (ADB).Retrieved on Dec. 25, 2024; https://www.adb.org/sites/default/files/publication/377761/mainstreaming-climate-risk-management.pdf
- ADB. (2013). Solid waste management in Nepal: current status and policy recommendations. Asian Development Bank (ADB).
- ADB. (2021). Nepal Climate Change Profile. Asian Development Bank (ADB), Kathmandu, Nepal.
- ADB. (2021). Nepal: Addressing Climate Change Challenges. Asian Development Bank (ADB), Kathmandu, Nepal.
- ADB. (2023). ADB Climate Change Reports for South Asia. Manila: Asian Development Bank, Kathmandu, Nepal.
- ADB. Projects. https://www.adb.org/projects
- ADB/Nepal. (2023). Sustainable Transport Projects for South Asia. Asian Development Bank, Kathmandu, Nepal.
- AEPC (2022) Annual Progress Report FY 2022/23. Alternative Energy Promotion Centre (AEPC). Kathmandu.Link: https://www.aepc.gov.np
- AEPC. (2023). Nepal Renewable Energy Status Report 2023. Alternative Energy Promotion Centre (AEPC), Kathmandu, Nepal.
- AEPC. (2023). Sustainable Energy for Rural Nepal. Alternative Energy Promotion Centre (AEPC), Kathmandu, Nepal.
- Akagi, S.K., Yokelson, R.J., Wiedinmyer, C., Alvarado, M.J., Reid, J.S., Karl, T., Crounse, J.D., & Wennberg, P.O. (2011). Emission factors for open and domestic biomass burning for use in atmospheric models. Atmospheric Chemistry and Physics, 11(9), 4039-4072.
- Alam, R., Chowdhury, M.A.I., Hasan, G.M.J., Karanjit, B., & Shrestha, L.R. (2008). Generation, storage, collection and transportation of municipal solid waste - A case study in the city of Kathmandu, capital of Nepal. J. Waste Management. Elsevier, 1088-1097.
- Bishwokarma, D., Sherchan, P., & Singh, P.M. (2021). Localizing Climate Actions in Nepal: The Role of Local Governments in Implementing National Climate Change Policy and Nationally Determined Contribution. Working Paper, Prakriti Resources Centre (PRC), Kathmandu, Nepal.
- CBS (2020). Waste management baseline survey of Nepal 2020. Central Bureau of Statistics (CBS), Government of Nepal.
- CBS. (1998). Census of Manufacturing Establishments 1996/97. Kathmandu, Nepal.
- CBS. (2002). Census of Manufacturing Establishments 2000/01. Kathmandu, Nepal.
- CBS. (2008). Census of Manufacturing Establishments 2006/07. Kathmandu, Nepal.
- CBS. (2012). National Population and Housing Census 2011. Kathmandu, Nepal.
- CBS. (2014a). Nepal Public Land Transport Survey 2013. Kathmandu, Nepal.
- CBS. (2014b). Development of Manufacturing Industries in Nepal. Kathmandu, Nepal.
- CBS. (2014c). National Census of Manufacturing Establishments-2011/12. Kathmandu, Nepal.
- CBS. (2018). National Economic Census 2018. Kathmandu: Central Bureau of Statistics.
- CBS. (2019). Nepal Standard Industrial Classification. Kathmandu, Nepal.
- CBS. (2022a). National Census 2078 (2021).
- CBS. (2022b). National Industrial Survey 2019/20. Kathmandu, Nepal.

- CBS. (2023). Economic Survey of Nepal 2022/23. Central Bureau of Statistics (CBS), Kathmandu, Nepal.
- CDKN. Climate & Development Knowledge Network. https://cdkn.org/projects
- Chaulagain, D. et al. (2024). Comprehensive Analysis of Land Use Change and Carbon Sequestration in Nepal from 2000 to 2050 Using Markov Chain and InVEST Models. Sustainability, 16(17), 7377.
- Christian, T.J., Yokelson, R.J., Cárdenas, B., Molina, L.T., Engling, G., & Hsu, S.C. (2010). Trace gas and particle emissions from domestic and industrial biofuel use and garbage burning in central Mexico. Atmospheric Chemistry and Physics, 10(2), 565-584.
- Climate Transparency Platform. https://climate-transparency-platform.org/projects
- CPC (2020). Baseline Study of Solid Waste Management in Kathmandu Metropolitan City.
- Das, B., Bhave, P.V., Puppala, S.P., Shakya, K., Maharjan, B., & Byanju, R.M. (2020). A model-ready emission inventory for crop residue open burning in the context of Nepal. Environmental Pollution, 266, 1-10. https://doi.org/10.1016/j.envpol.2020.115069
- Das, B., Bhave, P.V., Sapkota, A., & Byanju, R.M. (2018). Estimating emissions from open burning of municipal solid waste in municipalities of Nepal. Waste Management, 79, 481-490. https://doi.org/10.1016/j.wasman.2018.08.013
- Department of Electricity Development, DOED (2024), Electricity License Dashboard, Ministry of Energy, Water Resources and Irrigation (MoEWRI), Government of Nepal (GoN), July 2024. Link: http://www.doed.gov.np
- Department of Industry (2019). Detailed Study of Cement Manufacturing Industry in Nepal. Kathmandu: Government of Nepal.
- Department of Industry (2023). Industrial Statistics 2022/23. Kathmandu: Department of Industry.
- Department of Water Supply and Sewerage Management (DWSSM), Annual Progress Report FY 2022/23, Ministry of Water Supply, 2023. Link: https://dwssm.gov.np/
- DFRS. (2015). State of Nepal's Forest. Forest Resource Assessment (FRA). Kathmandu, Nepal.
- DOC (2022), Foreign Trade Statistics FY 2022/23, Department of Customs, Ministry of Finance, GoN, 2023. https://www.customs.gov.np
- DoHM/Nepal. (2017). Observed Climate Trend Analysis in the Districts and Physiographic Regions of DoHM/Nepal (1971-2014). Department of Hydrology and Meteorology, Kathmandu, Nepal.
- DoI. (2024). Industrial Statistics. Kathmandu, Nepal.
- DoTM. (2019). Vehicle Registration Data.
- EU. Delegation of the European Union to Nepal. https://www.eeas.europa.eu/delegations/nepal_en?s=237
- FAO Nepal. (2023). Climate-Smart Agriculture in the Himalayan Region.
- FAO. (2020). Emissions due to agriculture. Global, regional and country trends 2000–2018. FAOSTAT Analytical Brief Series No 18. Rome.
- FAO. (2022). The State of Agricultural Commodity Markets 2022. The geography of food and agricultural trade: Policy approaches for sustainable development. Rome, FAO. https://doi.org/10.4060/cc0471en
- FAO. (2023). Climate-Smart Agriculture Practices in South Asia. Food and Agriculture Organization.
- FAO. (2024). FAOSTAT. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. https://www.fao.org/faostat/en/#home (December 7, 2024).
- FRTC (2022), National Land Cover Monitoring System of Nepal, Forest Research and Training Centre (FRTC). Babarmahal, Kathmandu, Nepal. Ministry of Forests and Environment, 2022. Link: https://frtc.gov.np
- FRTC (2024). National Land Cover Monitoring System of Nepal, 2020- 2022. Forest Research and Training Centre (FRTC). Babarmahal, Kathmandu, Nepal. https://frtc.gov.np/uploads/files/

NLCMS_Report_Final.pdf

- Gautam, C. (2006). Final report on action program on air quality management of Kathmandu Valley. Ministry of Environment, Science and Technology, Government of Nepal.
- Gautam, M., & Agrawal, M. (2021). Greenhouse Gas Emissions from Municipal Solid Waste Management: A Review of Global Scenario. In: Muthu, S.S. (eds) Carbon Footprint Case Studies. Environmental Footprints and Eco-design of Products and Processes. Springer, Singapore. https://doi.org/10.1007/978-981-15-9577-6_5
- GCF. (2021). Nepal Country Profile. Green Climate Fund (GCF).
- GCF. (2022). Annual Report, Green Climate Fund (GCF).
- GCF. Green Climate Fund. https://www.greenclimate.fund/projects
- GCP. (2023). Global Carbon Project Supplemental data of Global Carbon Budget 2023 (Version 1.1) [Data set]. Global Carbon Project. https://doi.org/10.18160/gcp-2023
- GEF. (2023). Annual Report on Climate Action. Global Environment Facility (GEF) Secretariat.
- GEF. The Global Environment Facility (GEF). https://www.thegef.org/projects-operations/database
- Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A., & Tempio, G. (2013). Tackling Climate Change Through Livestock: A Global Assessment of Emissions and Mitigation Opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome.
- GGGI. Projects in Nepal. https://gggi.org/country/nepal/
- GHI. (2024). Nepal's hunger and nutrition status. Concern Worldwide and Welthungerhilfe.(https://www.globalhungerindex.org/pdf/en/2024/Nepal.pdf)
- GoN. (2022). Nationally Determined Contribution (NDC) Implementation Plan, Government of Nepal, Kathmandu.
- Government of Nepal. (2004). Initial National Communication to the Conference of the Parties of the United Nations Framework Convention on Climate Change. Ministry of Population and Environment, Government of Nepal, Singh Durbar, Kathmandu.
- Government of Nepal. (2014). Second National Communication to the United Nations Framework Convention on Climate Change. Ministry of Science, Technology, and Environment, Government of Nepal, Singh Durbar, Kathmandu.
- Government of Nepal. (2021). Third National Communication to the United Nations Framework Convention on Climate Change. Ministry of Forests and Environment, Singha Durbar, Kathmandu, Nepal.
- Heaps, C. (2024). LEAP - Low Emission Analysis Platform.
- ICIMOD. (2022). Climate Change in the Himalayas: Risks and Adaptation Needs. ICIMOD, Lalitpur, Nepal.
- ICIMOD. (2023). Hydrological Modelling and Data Integration for the Himalayas. International Centre for Integrated Mountain Development (ICIMOD), Nepal.
- ICIMOD. (2023). Technical Reports on RE and Mitigation Strategies for Nepal. International Centre for Integrated Mountain Development, Nepal.
- IPCC. (1995). IPCC Second Assessment Report: Climate Change. Geneva: Intergovernmental Panel on Climate Change.
- IPCC. (1996). Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Industrial Processes. Geneva: Intergovernmental Panel on Climate Change.
- IPCC. (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3 Industrial Processes and Product Use. Geneva: Intergovernmental Panel on Climate Change.
- IPCC. (2007). IPCC Fourth Assessment Report: Climate Change. Geneva: Intergovernmental Panel on Climate Change.
- IPCC. (2014). IPCC Fifth Assessment Report: Climate Change. Geneva: Intergovernmental Panel

on Climate Change.

- IPCC. (2019). IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems - Summary for Policymakers. https://www.ipcc.ch/site/assets/uploads/2019/08/Fullreport.pdf
- IPCC. (2019). IPCC Updates Methodology for Greenhouse Gas Inventories, Intergovernmental Panel for Climate Change (IPCC), Switzerland.
- IPCC. (2023). IPCC Emission Factor Database. Geneva: Intergovernmental Panel on Climate Change.
- Jayarathne, T., Stockwell, C.E., Bhave, P.V., Praveen, P.S., Rathnayake, C.M., Islam, M.R., Panday, A.K., Adhikari, S., Maharjan, R., Goetz, J.D., & DeCarlo, P.F. (2018). Nepal Ambient Monitoring and Source Testing Experiment (NAMaSTE): emissions of particulate matter from wood-and dung-fueled cooking fires, garbage and crop residue burning, brick kilns, and other sources. Atmospheric Chemistry and Physics, 18(3), 2259-2286.
- KMC. (2023). Urban Climate Resilience Programs Report. Kathmandu Metropolitan City (KMC).
- Laconde, T., & Association Climate Chance, 10 Rue des Prairies, 75020 Paris (France). (2018). Fugitive emissions: a blind spot in the fight against climate change. Fugitives emissions - Sector profile.
- Lal, S.H., Bajracharya, R.M., & Sitaula, B.K. (2012). Forest and Soil Carbon Stocks, Pools and Dynamics and Potential Climate Change Mitigation in Nepal. J. Environ. Sci. Eng, 1, 800-811.
- Lohani, B.N., & Thanh, N.C. (1978). Waste Disposal and Resources Recovery.
- Maharjan, M.K., & Lohani, S. (2019). Municipal solid waste management in Nepal: Opportunities and challenges. Journal of the Institute of Engineering, 15(3), 222-226.
- Malla, S. (2014). Assessment of mobility and its impact on energy use and air pollution in Nepal. Energy, 69, 485–496. https://doi.org/10.1016/j.energy.2014.03.041
- Management and Resource Mobilization Centre, Lalitpur.
- Ministry of Agriculture and Livestock Development (MoALD). (1994-2022). Statistical information on Nepalese agriculture. Government of Nepal, Singha Durbar, Kathmandu.
- Ministry of Agriculture and Livestock Development (MoALD). (2015). Statistical information on Nepalese agriculture. Government of Nepal, Singha Durbar, Kathmandu.
- Ministry of Agriculture and Livestock Development (MoALD). (2023). Statistical information on Nepalese agriculture. Government of Nepal, Singha Durbar, Kathmandu.
- Ministry of Finance (2022), Budget Speech of Fiscal Year 2022/23, June 2022. Link: https://mof.gov.np
- Ministry of Finance. (2023). Economic Survey 2022/23. Kathmandu: Ministry of Finance.
- Ministry of Physical Infrastructure and Transport (MoPIT), Annual Progress Report FY 2022/23, GoN, 2023. Link: https://www.mopit.gov.np
- MoCTCA, (2024). Nepal Tourism Statistics 2023. Ministry of Culture, Tourism and Civil Aviation (MoTCA), Government of Nepal.
- MoEWRI. (2018). Present situation and future roadmap of the energy, water resources, and irrigation sector (White Paper). Government of Nepal.
- MoF (Ministry of Finance). (2024). Economic Bulletin 2080/81. Government of Nepal.
- MoF. (2023). Economic Survey 2022/23. Kathmandu: Ministry of Finance.(MoF), Singhadarwar, Kathmandu,Nepal.
- MoF/GoN. (2012). Climate Change Budget Code and its Implementation Guidelines. Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. (2012). Statement of Technical and Other Assistance FY 2012/13, (From Bilateral and Multilateral Sources including INGOs), Ministry of Finance, Kathmandu, Nepal.

- MoF/GoN. (2013). Statement of Technical and Other Assistance FY 2013/14, (From Bilateral and Multilateral Sources including INGOs), Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. (2015). Statement of Technical and Other Assistance FY 2015/16, (From Bilateral and Multilateral Sources including INGOs), Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. (2016). Statement of Technical and Other Assistance FY 2016/17, (From Bilateral and Multilateral Sources including INGOs), Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. (2017). Statement of Technical and Other Assistance FY 2017/18 (From Bilateral and Multilateral Sources including INGOs), Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. (2018). Statement of Technical and Other Assistance FY 2018/19 (From Bilateral and Multilateral Sources including INGOs), Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. (2019). Statement of Technical and Other Assistance FY 2019/20 (From Bilateral and Multilateral Sources including INGOs), Ministry of Finance.
- MoF/GoN. (2020). Budget Speech of Fiscal Year 2020/21. Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. (2020). Statement of Technical and Other Assistance FY 2020/21 (From Bilateral and Multilateral Sources including INGOs), Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. (2021). Redbook: Budget Appropriations for Fiscal Year 2021/22. Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. (2021). Statement of Technical and Other Assistance FY 2021/22 (From Bilateral and Multilateral Sources including INGOs), Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. (2022). Statement of Technical and Other Assistance FY 2022/23 (From Bilateral and Multilateral Sources including INGOs), Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. (2023). National Budget Reports on Climate Finance. Kathmandu: Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. (2023). Nepal Foreign Trade Statistics, Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. (2023). Statement of Technical and Other Assistance FY 2023/24 (From Bilateral and Multilateral Sources including INGOs), Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. (2024). Economic Survey: Fiscal Reports [WWW Document]. URL https://www.mof.gov.np/site/publication-category/21 (accessed 1.1.24).
- MoF/GoN. (2024). Statement of Technical and Other Assistance FY 2024/25 (From Bilateral and Multilateral Sources including INGOs), Ministry of Finance, Kathmandu, Nepal.
- MoF/GoN. AID Management Information System for Nepal. https://amis.mof.gov.np
- MoF/GoN. Development Finance Information Management System (DFIMS). https://dfims.mof.gov.np/
- MoFE. (2018). Nepal's sixth national report to the Convention on Biological Diversity. Ministry of Forests and Environment(MoFE),Government of Nepal.
- MoFE. (2021b). Vulnerability and Risk Assessment and Identifying Adaptation Options: Summary for Policy Makers. Ministry of Forests and Environment, Government of Nepal. Kathmandu, Nepal.
- MoFE. (2021c). Vulnerability and Risk Assessment and Identifying Adaptation Options in GESI, Livelihood and Socio-Economic Sector in Nepal. Ministry of Forests and Environment, Government of Nepal. Kathmandu, Nepal.
- MoFE. (2021d). Nepal's third national communication to the United Nations Framework Convention on Climate Change (UNFCCC). Climate Change Management Division, Government of Nepal.
- MoFE/GoN. (2019). Climate Change Policy 2019. Kathmandu: Ministry of Forests and Environment, Nepal.
- MoFE/GoN. (2019). Climate change scenarios for Nepal for National Adaptation Plan (NAP). Ministry of Forests and Environment, Kathmandu, Nepal.
- MoFE/GoN. (2020). Nepal's Nationally Determined Contributions. Kathmandu: Ministry of Forests

and Environment, Kathmandu, Nepal.

- MoFE/GoN. (2020). Study and Review of CCA Interventions and Researches in Nepal to Plan Future Investments in Adaptation across the Key Economic Sectors: Review and synthesis of Nepal's past and current adaptation measures and assess of their effectiveness for planning and advancing the NAP process in Nepal: Ministry of Forests and Environment, Government of Nepal. Retrieved on Dec. 30, 2024; www.climatenepal.org.np/sites/default/files/doc_resources/Component-1_Study-and-Review-of-CCA-Intervention-in-Nepal.pdf
- MoFE/GoN. (2021). Nepal's Long-Term Strategy for Net-Zero Emissions. Kathmandu, Nepal.
- MoFE/GoN. (2021a). National Adaptation Plan (NAP) 2021-2050. Ministry of Forests and Environment, Kathmandu, Nepal.
- MoFE/GoN. (2021a). Technology Needs Assessment for Adaptation Technologies, Ministry of Forests and Environment, Singha Durbar, Kathmandu, Nepal.
- MoFE/GoN. (2022). Climate Change Finance in Nepal: An Overview of External Support and Expenditure Trends. Kathmandu,Nepal.
- MoFE/GoN. (2022). National Adaptation Plan to Address Climate Change. Ministry of Forests and Environment, Kathmandu, Nepal.
- MoFE/GoN. (2023). Nationally Determined Contribution Implementation Plan (2021-2030), Ministry of Forest and Environment, Nepal.
- MoFE/GoN. (2023). Nepal's National Adaptation Plan. Ministry of Forests and Environment, Kathmandu, Nepal.
- MoFE/GoN. (2024). National Land Cover Monitoring System for Nepal. https://servir.icimod.org/science-applications/national-land-cover-monitoring-system-nepal/ (December 7, 2024).
- MoHA. (2018). Disaster risk reduction national strategic plan of action 2018–2030. Government of Nepal.
- MoHP (2022). Vulnerability and Adaptation Assessment of Climate Sensitive Diseases and Health Risks in Nepal. Ministry of Health and Population, Government of Nepal, Kathmandu, Nepal
- MoHP 2023.Nepal Demographic and Health Survey 2022, Ministry of Health and Population(MoHP) ,Ram Shah Path, Kathmandu, Nepal.
- MOICS. (2024). Improvement plan 2024. Ministry of Industry, Commerce and Supplies (MOICS),Kathmandu,Nepal.
- MoPIT/GoN. (2023). Transport Emissions Reduction Roadmap. Ministry of Physical Infrastructure and Transport, Kathmandu, Nepal.
- MoUD/GoN. (2023). National Urban Green Development Framework.Ministry of Urban Development (MoUD), Kathmandu, Nepal.
- Nagpure, A.S., Ramaswami, A., & Russell, A. (2015). Characterizing the spatial and temporal patterns of open burning of municipal solid waste (MSW) in Indian cities. Environmental Science & Technology, 49(21), 12904-12912. https://doi.org/10.1021/acs.est.5b03243
- National Lake Conservation Development Committee (NLCDC). (n.d.). Home. Government of Nepal. Retrieved May 7, 2025, from https://nepallake.gov.np/home/
- NCCKMC. Nepal Climate Change and Development Portal, Nepal Climate Change Knowledge Management Center (NCCKMC). www.climatenepal.org.np
- NCF. Nordic Development Fund, Nordic Climate Facility (NCF). https://www.nordicclimatefacility.com/projects
- NEA. (2020). Generation Directorate 2077/2078: 13th Issue. Darbarmargha,Kathmandu. https://www.nea.org.np/admin/assets/uploads/annual_publications/Generation_2020.pdf
- NEA. (2023), Annual Report FY 2022/23, MoEWRI, GoN, 2023. Link: https://www.nea.org.np/

- NEA. (2024). A year in review fiscal year 2023/24. Nepal Electricity Authority (NEA) Government of Nepal.
- NEA-GD. (2020). Generation Magazine. Kathmandu, Nepal.
- NEA-GD. (2023). Generation Magazine. Kathmandu, Nepal.
- Nepal Climate Change & Development Portal. www.climatenepal.org.np
- Nepal Rastra Bank. (2021). Socio-economic Impact of Foreign Direct Investment in Cement Industry in Nepal. Kathmandu: Nepal Rastra Bank.
- NOC. (2024). Monthly Import and Sales [WWW Document]. URL https://noc.org.np/import (accessed 3.3.24).
- NPC. (2024). Sixteenth Plan (FY 2081/82–2085/86) (p. 125). Government of Nepal.
- NPC/GoN. (2014). Nepal's National Climate Change Financing Framework and Implementation Guidelines. National Planning Commission (NPC), Kathmandu, Nepal.
- NPC/GoN. (2017). Climate Change Financing Framework: A Roadmap to Systematically Mainstream Climate Change in Nepal's Public Financial Management System. Kathmandu, Nepal.
- NSO (National Statistics Office). (2024). Nepal Labour Force Survey 2022–2023.National Statistics Office (NSO), Government of Nepal.
- NSO. (2021), National Population and Housing Census 2021.National Satirical Office (NSO), Office of the Prime Minister and Council of Ministers,
- NSO. (2023). GDP-Historical-Series [WWW Document]. Natl. Accounts Stat. URL https://nsonepal.gov.np/category/1065/
- NSO. (2023). National Sample Census of Agriculture 2021/22: National Report. National Statistics Office (NSO), Government of Nepal.
- NSO. (2024), National Climate Change Survey 2022, Nepal Statistical Office (NSO) Kathmandu, Nepal. Link: https://nsonepal.gov.np
- NSO. (2024). Degree of Urbanization (DEGURBA) in Nepal. Kathmandu, Nepal.
- NSO. (2024). Environment Statistics of Nepal 2019. Kathmandu, Nepal.
- NSO. (2024a). Nepal Living Standards Survey IV 2022/23. National Statistics Office (NS0),Government of Nepal. Kathmandu. (https://data.nsonepal.gov.np/dataset/b6c3c19b-4b15-44bf-8653-1571e76dad14/resource/e2d52301-1c25-498b-8732-4326c62a2372/download/nlss-iv.pdf)
- OECD. (2022). DAC Reports on Climate Finance Mobilization. Paris: Organisation for Economic Co-operation and Development (OECD).Oxford Policy Management. https://www.opml.co.uk/our-work
- Pathak, D. R., and P. Pokhrel. "The Impact of COVID-19 on Quantification and Characterization of Solid Waste in the Bagmati River Corridor of Kathmandu Valley, Nepal." Solid Waste 2023 (2023): 377.
- PDMO (2024). Annual Report of Public Debt, 2080/81. PDMO Public Debt Management Office (PDMO) (Government of Nepal, Ministry of Finance. Kathmandu, Nepal.
- Pokhrel, D. (2013). Energy revolution [WWW Document]. ekantipur. URL https://leadersnepal.org.np/energy-revolution/ (accessed 10.1.24).
- Practical Action Nepal. (2008). Best Practices on Solid Waste Management of Nepalese Cities.
- PRC. (2021). Climate Finance Options for Nepal, Prakriti Resources Centre (PRC), Nepal.
- Rai, S., Chhetri, R.P., & Dhital, B. (2020). Climate Adaptation Finance Study Report Nepal. Kathmandu: CARE Nepal.
- REDD+ Nepal. (2023). Forest-Based Solutions for Climate Resilience.
- REDD+ Nepal. (2023). Sustainable Forest Management and Carbon Sequestration in Nepal.

- RFTF. (2024). Agricultural Greenhouse Gas Emissions 101. Available at https://www.rff.org/publications/explainers/agricultural-greenhouse-gas-emissions-101/
- Ritchie, H. (2019). Food production is responsible for one-quarter of the world's greenhouse gas emissions. Published online at OurWorldinData.org. Retrieved from: 'https://ourworldindata.org/food-ghg-emissions' [Online Resource]
- Shrestha, R.M. (2018). Emissions of air pollutants and greenhouse gases in Nepal, an integrated inventory. A study carried out for Regional Resource Centre for Asia and the Pacific (RRC.AP) as a part of activities of Project Atmospheric Brown Cloud, Regional Energy Resources Information Center (RERIC), Asian Institute of Technology, Thailand.
- Switch Asia Programme. https://www.switch-asia.eu/project/ppp4gs/
- SWMRMC, (2004): A Diagnostic Report on State of Solid Waste Management in Municipalities of Nepal, Solid Waste. Solid Waste Management and Resource Mobilisation Centre (SWMRMC), Lalitpur, Nepal.
- SWMRMC/UN-HABITAT (2008) 10 Steps for a Clean City Technical Guidelines for Solid Waste Management in Nepal (Draft), Solid Waste Management and Resource Mobilisation Centre (SWMRMC), Lalitpur, Nepal.
- SWMTSC (2015. Environment audit report (Unofficial translation). Solid Waste Management Technical Support Centre (SWMTSC).Ministry of Urban Development., Kathmandu, Nepal.
- THT. (2012). Diesel plant in Hetauda generates electricity [WWW Document]. Himal. Times. URL https://www.sharesansar.com/newsdetail/diesel-plant-in-hetauda-generates-electricity (accessed 10.1.24).
- UKaid Development Tracker. https://devtracker.fcdo.gov.uk/
- UN. (1989). International Standard Industrial Classification. New York.
- UN-DESA. (2008). International Standard Industrial Classification of All Economic Activities.
- UNEP Copenhagen Climate Centre. (2021). Technology Needs Assessment for Nepal: Final Report. Retrieved from UNEP TNA Report.
- UNFCCC. (2011). Decision 2/CP.17: Biennial Update Reports for Non-Annex I Countries. Retrieved from UNFCCC website.
- UNFCCC. (2015). Paris Agreement. Bonn: United Nations Framework Convention on Climate Change. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
- UNFCCC. (2018). Modalities, Procedures, and Guidelines for the Enhanced Transparency Framework. United Nations Framework Convention on Climate Change. https://unfccc.int/documents/193407
- UNFCCC. (2019). Katowice Climate Package. United Nations Framework Convention on Climate Change. https://unfccc.int/katowice
- UNFCCC. (2020). Guidelines for the Preparation of National Communications from Parties not included in Annex I to the Convention. Bonn: UNFCCC.
- UNFCCC. (2023). Nepal's National Communications to the UNFCCC.
- UNFCCC. (2024). Guyana first biennial transparency report (February 2024). Retrieved from Guyana First Biennial Transparency Report (February 2024).
- United Nations. (1990). International Standard Industrial Classification of All Economic Activities (ISIC), Rev.3. New York: United Nations.
- United Nations. (2008). International Standard Industrial Classification of All Economic Activities (ISIC), Rev.4. New York: United Nations.
- Wang, X., Chang, X., Ma, L., Bai, J., Liang, M., & Yan, S. (2023). Global and regional trends in greenhouse gas emissions from rice production, trade, and consumption. Environmental Impact Assessment Review, 101, 107141. https://doi.org/10.1016/j.eiar.2023.107141

- WBG. (2022). Nepal Country Climate and Development Report. World Bank Group CCDR Series. © World Bank, Washington, DC. http://hdl.handle.net/10986/38012
- WECS 2019. Microsoft Word - Final Report July 2019 on hydropower potential. Reports and Publications Water and Energy Commission Secretariat
- WECS. (1994). Energy Sector Synopsis Report 1992/93. Kathmandu, Nepal.
- WECS. (1996). Energy Synopsis Report Nepal 1994/95. Kathmandu, Nepal.
- WECS. (2010). Energy Sector Synopsis Report 2010. Water Energy Comm. Secr. 1–116.
- WECS. (2013). National Survey of Energy Consumption and Supply Situation in Nepal. Kathmandu, Nepal.
- WECS. (2014). Energy Data Sheet. Kathmandu, Nepal.
- WECS. (2021a). Energy Consumption and Supply Situation in Federal System of Nepal - Province 1 (Koshi Pradesh).
- WECS. (2021b). Energy Consumption and Supply Situation in Federal System of Nepal - Province 2 (Madhesh Pradesh).
- WECS. (2022a). Energy Consumption and Supply Situation in Federal System of Nepal - Bagmati Province.
- WECS. (2022b). Energy Sector Synopsis Report 2022. Kathmandu, Nepal.
- WECS. (2023). Energy Synopsis Report 2023. Kathmandu, Nepal.
- WECS. (2024). Energy Consumption and Supply Situation in Federal System of Nepal - Gandaki, Lumbini, Karnali and Sudurpaschim Provinces (Unpublished).
- WECS. (2024). Energy sector synopsis report 2024. Water and Energy Commission Secretariat (WECS).Government of Nepal.
- Wiedinmyer, C., Yokelson, R.J., & Gullett, B.K. (2014). Global emissions of trace gases, particulate matter, and hazardous air pollutants from open burning of domestic waste. Environmental Science & Technology, 48(16), 9523-9530.
- World Bank. (2022). Climate Action in South Asia: Scaling Climate Solutions.
- World Bank. (2022). Climate Support in Nepal. Washington, D.C.: World Bank.
- World Bank. (2022). Resilient Nepal: Strengthening Climate Action.
- World Bank. (2023). World Development Indicators [WWW Document]. World Dev. Indic. Databse Arch. URL https://databank.worldbank.org/source/wdi-database-archives# (accessed 11.1.24).
- WWF. Projects. https://www.worldwildlife.org/projects/

Annexes

Annex I.

Annex I.I Global Warming Potentials

	CO_2	CH_4	N_2O	HFC134a
SAR	1	21	310	1300
AR4	1	25	298	1430
AR5	1	28	265	1300

IPCC Inventory Software V2.95

Annex II. Summary on GHG Emissions

Annex II.I Summary for the year 1994

Inventory Year: 1994	Emissions (Gg)		
Categories	Net CO_2	CH_4	N_2O
Total National Emissions and Removals	-9,073.2226	830.2918	8.8265
1 - Energy	1,470.1612	304.3570	1.8601
1.A - Fuel Combustion Activities	1,470.1612	304.3570	1.8601
1.A.1 - Energy Industries	40.8505	0.0016	0.0003
1.A.2 - Manufacturing Industries and Construction	307.5633	0.2464	0.0335
1.A.3 - Transport	520.6853	0.0538	0.0389
1.A.4 - Other Sectors	601.0621	304.0551	1.7874
2 - Industrial Processes and Product Use	155.9239	0	0
2.A - Mineral Industry	155.9239	0	0
2.A.1 - Cement production	155.9239		
3 - Agriculture, Forestry, and Other Land Use	-10,715.6719	515.2549	6.4778
3.A - Livestock	0	442.4686	0.9124
3.A.1 - Enteric Fermentation		407.4425	
3.A.2 - Manure Management		35.0261	0.9124
3.B - Land	-10791.4938	0	0
3.B.1 - Forest land	-10791.4938		
3.C - Aggregate sources and non-CO2 emissions sources on land	75.8219	72.7863	5.5654
3.C.2 - Liming	0.1411		
3.C.3 - Urea application	75.6807		
3.C.4 - Direct N2O Emissions from managed soils			3.9161
3.C.5 - Indirect N2O Emissions from managed soils			1.5544
3.C.6 - Indirect N2O Emissions from manure management			0.0948
3.C.7 - Rice cultivation		72.78627	
4 - Waste	16.3643	10.6800	0.4886
4.A - Solid Waste Disposal		1.10182	
4.B - Biological Treatment of Solid Waste		0.0246	0.0014

4.C - Incineration and Open Burning of Waste	16.3643	0.5142	0.0065
4.D - Wastewater Treatment and Discharge		9.0394	0.4807

Annex II.II Summary for the year 1995

Inventory Year: 1995	Emissions (Gg)		
Categories	Net CO_2	CH_4	N_2O
Total National Emissions and Removals	-8957.1239	852.2632	9.2146
1 - Energy	1569.6752	312.6737	1.9084
1.A - Fuel Combustion Activities	1569.6752	312.6737	1.9084
1.A.1 - Energy Industries	53.1380	0.0021	0.0004
1.A.2 - Manufacturing Industries and Construction	326.9787	0.2535	0.0345
1.A.3 - Transport	560.1062	0.0592	0.0422
1.A.4 - Other Sectors	629.4523	312.3588	1.8313
2 - Industrial Processes and Product Use	161.5206	0	0
2.A - Mineral Industry	161. 5206	0	0
2.A.1 - Cement production	161. 5206		
3 - Agriculture, Forestry, and Other Land Use	-10705.0276	527.5106	6.7854
3.A - Livestock	0	458.8406	0.9364
3.A.1 - Enteric Fermentation		422.5109	
3.A.2 - Manure Management		36.3297	0.9364
3.B - Land	-10791.4938	0	0
3.B.1 - Forest land	-10791.4938		
3.C - Aggregate sources and non-CO2 emissions sources on land	86.4662	68.6701	5.849
3.C.2 - Liming	0.1411		
3.C.3 - Urea application	86.3251		
3.C.4 - Direct N2O Emissions from managed soils			4.1081
3.C.5 - Indirect N2O Emissions from managed soils			1.6435
3.C.6 - Indirect N2O Emissions from manure management			0.0974
3.C.7 - Rice cultivation		68.67005	
4 - Waste	16.7079	12.0789	0.5208
4.A - Solid Waste Disposal		1.9372	
4.B - Biological Treatment of Solid Waste		0.0263	0.0015
4.C - Incineration and Open Burning of Waste	16.7079	0.5259	0.0066
4.D - Wastewater Treatment and Discharge		9.5895	0.5127

Annex II.III Summary for the year 2001

Inventory Year: 2001	Emissions (Gg)		
Categories	Net CO_2	CH_4	N_2O
Total National Emissions and Removals	-7680.0662	920.1561	9.3319
1 - Energy	2963.8170	319.9314	1.8269
1.A - Fuel Combustion Activities	2963.8170	319.9314	1.8269

1.A.1 - Energy Industries	16.3910	0.00070	0.0001
1.A.2 - Manufacturing Industries and Construction	795.6870	0.13192	0.0191
1.A.3 - Transport	978.4870	0.1062	0.0789
1.A.4 - Other Sectors	1173.2523	319.6926	1.7288
2 - Industrial Processes and Product Use	106.2993	0	0
2.A - Mineral Industry	106.2993	0	0
2.A.1 - Cement production	106.2993		
3 - Agriculture, Forestry, and Other Land Use	-10769.6990	576.8333	6.7396
3.A - Livestock	0	492.2246	1.0521
3.A.1 - Enteric Fermentation		452.2601	
3.A.2 - Manure Management		39.9645	1.0521
3.B - Land	-10791.4938	0	0
3.B.1 - Forest land	-10791.4938		
3.C - Aggregate sources and non-CO2 emissions sources on land	21.7950	84.6087	5.6875
3.C.2 - Liming	0.1411		
3.C.3 - Urea application	21.6540		
3.C.4 - Direct N2O Emissions from managed soils			4.038
3.C.5 - Indirect N2O Emissions from managed soils			1.5236
3.C.6 - Indirect N2O Emissions from manure management			0.1259
3.C.7 - Rice cultivation		84.6087	
4 - Waste	19.5164	23.3914	0.7654
4.A - Solid Waste Disposal		4.8833	
4.B - Biological Treatment of Solid Waste		0.0386	0.0022
4.C - Incineration and Open Burning of Waste	19.5164	0.6104	0.0077
4.D - Wastewater Treatment and Discharge		17.8590	0.7554

Annex II.IV Summary for the year 2011

Inventory Year: 2011	Emissions (Gg)		
Categories	Net CO_2	CH_4	N_2O
Total National Emissions and Removals	-5186.0878	1098.6338	12.2549
1 - Energy	4148.8273	378.6908	2.2829
1.A - Fuel Combustion Activities	4148.8273	378.6908	2.2829
1.A.1 - Energy Industries	2.4820	0.00010	0.00002
1.A.2 - Manufacturing Industries and Construction	1407.6338	0.3753	0.0528
1.A.3 - Transport	1747.7073	0.2792	0.1582
1.A.4 - Other Sectors	991.0043	378.0361	2.0718
2 - Industrial Processes and Product Use	354.8331	0	0
2.A - Mineral Industry	350.3822	0	0
2.A.1 - Cement production	350.3822		
2.D - Non-Energy Products from Fuels and Solvent Use	4.4509	0	0
2.D.1 - Lubricant Use	3.0785		

2.D.2 - Paraffin Wax Use	1.3724		
3 - Agriculture, Forestry, and Other Land Use	-9725.3751	684.8944	8.8981
3.A - Livestock	0	600.7008	1.4241
3.A.1 - Enteric Fermentation		551.3984	
3.A.2 - Manure Management		49.3024	1.4241
3.B - Land	-9787.9896	0	0
3.B.1 - Forest land	-13063.0981		
3.B.2 - Cropland	1300.2607		
3.B.3 - Grassland	2113.2524		
3.B.5 - Settlements	-138.4046		
3.C - Aggregate sources and non-CO2 emissions sources on land	62.6145	84.1937	7.4741
3.C.2 - Liming	0.1411		
3.C.3 - Urea application	62.4734		
3.C.4 - Direct N2O Emissions from managed soils			5.2301
3.C.5 - Indirect N2O Emissions from managed soils			2.0425
3.C.6 - Indirect N2O Emissions from manure management			0.2015
3.C.7 - Rice cultivation		84.1937	
4 - Waste	35.6268	35.0486	1.0739
4.A - Solid Waste Disposal		8.8292	
4.B - Biological Treatment of Solid Waste		0.057	0.0033
4.C - Incineration and Open Burning of Waste	35.6268	0.7956	0.0112
4.D - Wastewater Treatment and Discharge		25.3668	1.0594

Annex II.V Summary for the year 2022

Inventory Year: 2022	Emissions (Gg)			
Categories	Net CO2	CH4	N2O	HFCs
Total National Emissions and Removals	-1474.073	1235.852	19.115	0.013
1 - Energy	13567.620	383.423	2.682	-
1.A - Fuel Combustion Activities	13567.620	383.423	2.682	-
1.A.1 - Energy Industries	0.023	0.000	0.000	
1.A.2 - Manufacturing Industries and Construction	6999.824	2.157	0.301	
1.A.3 - Transport	4629.203	0.861	0.410	
1.A.4 - Other Sectors	1938.570	380.405	1.971	
2 - Industrial Processes and Product Use	4,794.891	-	-	0.013
2.A - Mineral Industry	4792.239	-	-	-
2.A.1 - Cement production	4792.239			
2.D - Non-Energy Products from Fuels and Solvent Use	2.652	-	-	-
2.D.1 - Lubricant Use	1.900			
2.D.2 - Paraffin Wax Use	0.752			

2.F - Product Uses as Substitutes for Ozone Depleting Substances	-	-	-	0.013
2.F.1 - Refrigeration and Air Conditioning	-	-	-	0.013
3 - Agriculture, Forestry, and Other Land Use	-19916.207	733.118	11.172	-
3.A - Livestock	-	650.000	1.976	-
3.A.1 - Enteric Fermentation		595.951		
3.A.2 - Manure Management		54.048	1.976	
3.B - Land	-20021.958	-	-	-
3.B.1 - Forest land	-18072.100			
3.B.2 - Cropland	6345.516			
3.B.3 - Grassland	-38.794			
3.B.5 - Settlements	-8256.580			
3.C - Aggregate sources and non-CO2 emissions sources on land	105.751	83.119	9.197	-
3.C.2 - Liming	0.531			
3.C.3 - Urea application	105.220			
3.C.4 - Direct N2O Emissions from managed soils			6.314	
3.C.5 - Indirect N2O Emissions from managed soils			2.576	
3.C.6 - Indirect N2O Emissions from manure management			0.307	
3.C.7 - Rice cultivation		83.119		
4 - Waste	79.623	119.311	5.260	-
4.A - Solid Waste Disposal		48.682		
4.B - Biological Treatment of Solid Waste		0.320	0.018	
4.C - Incineration and Open Burning of Waste	79.623	1.590	0.024	
4.D - Wastewater Treatment and Discharge		68.718	5.218	

Annex III. Key Category Analysis

Annex III.I Trend Assessment

Code	IPCC Category	Greenhouse gas	2012 Year Estimate Ex0 (Gg CO_2-eq)	2022 Year Estimate Ext (Gg CO_2-eq)	Trend Assessment (Txt)	% Contribution to Trend	Cumulative Total of Column G
3.B.1.a	Forest land Remaining Forest land	CARBON DIOXIDE (CO_2)	-13,220.3291	-18,072.1001	0.1757	0.19877	0.19877
3.B.5.a	Settlements Remaining Settlements	CARBON DIOXIDE (CO_2)	- 143.5428	- 8,256.5802	0.1490	0.1686	0.3673
3.A.1	Enteric Fermentation	METHANE (CH_4)	15,736.5304	16,686.6350	0.0864	0.0977	0.4650
3.B.2.a	Cropland Remaining Cropland	CARBON DIOXIDE (CO_2)	1,346.6755	6,345.5164	0.0823	0.0932	0.5582
2.A.1	Cement production	CARBON DIOXIDE (CO_2)	470.7781	4,792.2391	0.0758	0.0857	0.6439
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CARBON DIOXIDE (CO_2)	1,301.0243	5,437.1350	0.0669	0.0757	0.7196
3.B.3.a	Grassland Remaining Grassland	CARBON DIOXIDE (CO_2)	2,346.2852	- 38.7942	0.0590	0.0667	0.7863
1.A.3.b	Road Transportation - Liquid Fuels	CARBON DIOXIDE (CO_2)	1,449.4901	3,930.5052	0.0357	0.0404	0.8267
1.A.4	Other Sectors - Biomass - solid	METHANE (CH_4)	8,819.1665	10,645.4025	0.0248	0.0281	0.8548
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CARBON DIOXIDE (CO_2)	359.8886	1,562.6890	0.0196	0.0221	0.8769
4.A	Solid Waste Disposal	METHANE (CH4)	262.9611	1,363.1061	0.0183	0.0208	0.8977
3.C.7	Rice cultivation	METHANE (CH4)	2,412.5856	2,327.3374	0.0175	0.0197	0.9174

Code	IPCC Category	Greenhouse gas	2012 Year Estimate Ex0 (Gg CO_2-eq)	2022 Year Estimate Ext (Gg CO_2-eq)	Trend Assessment (Txt)	% Contribution to Trend	Cumulative Total of Column G
4.D	Wastewater Treatment and Discharge	NITROUS OXIDE (N2O)	324.4785	1,382.8449	0.0172	0.0194	0.9368
4.D	Wastewater Treatment and Discharge	METHANE (CH4)	723.5664	1,924.1072	0.0171	0.0194	0.9562
1.A.4	Other Sectors - Liquid Fuels	CARBON DIOXIDE (CO2)	962.3502	1,880.5799	0.0104	0.0118	0.9680
3.A.2	Manure Management	METHANE (CH4)	1,410.8394	1,513.3330	0.0074	0.0084	0.9764
3.C.4	Direct N2O Emissions from managed soils	NITROUS OXIDE (N2O)	1,435.6056	1,673.1809	0.0051	0.0058	0.9822
1.A.3.e	Other Transportation - Liquid Fuels	CARBON DIOXIDE (CO2)	203.1501	539.5417	0.0048	0.0054	0.9876
1.A.4	Other Sectors - Biomass - solid	NITROUS OXIDE (N2O)	439.3252	498.1143	0.0018	0.0021	0.9897
3.C.5	Indirect N2O Emissions from managed soils	NITROUS OXIDE (N2O)	565.9892	682.5518	0.00168	0.0018	0.9915
1.A.4	Other Sectors - Solid Fuels	CARBON DIOXIDE (CO2)	101.5436	57.9898	0.0015	0.0017	0.9932
1.A.3.a	Civil Aviation - Liquid Fuels	CARBON DIOXIDE (CO2)	58.8789	159.1565	0.0014	0.0016	0.9948
1.A.2	Manufacturing Industries and Construction - Biomass - solid	NITROUS OXIDE (N2O)	10.9089	53.7116	0.0007	0.0008	0.9956
1.A.2	Manufacturing Industries and Construction - Biomass - solid	METHANE (CH4)	8.6448	42.5639	0.0006	0.0006	0.9962
1.A.3.e	Other Transportation - Liquid Fuels	NITROUS OXIDE (N2O)	20.7784	55.1847	0.0005	0.0006	0.9968

Code	IPCC Category	Greenhouse gas	2012 Year Estimate Ex0 (Gg CO_2-eq)	2022 Year Estimate Ext (Gg CO_2-eq)	Trend Assessment (Txt)	% Contribution to Trend	Cumulative Total of Column G
1.A.3.b	Road Transportation - Liquid Fuels	NITROUS OXIDE (N2O)	19.2621	52.3055	0.0005	0.0005	0.9973
4.C	Incineration and Open Burning of Waste	CARBON DIOXIDE (CO2)	44.6955	79.6233	0.0003	0.0004	0.9977
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	-	16.7026	0.0003	0.0003	0.9981
1.A.2	Manufacturing Industries and Construction - Solid Fuels	NITROUS OXIDE (N2O)	5.4668	22.8463	0.0003	0.0003	0.9984
1.A.3.b	Road Transportation - Liquid Fuels	METHANE (CH4)	7.8535	23.2206	0.0002	0.0003	0.9986
1.A.2	Manufacturing Industries and Construction - Solid Fuels	METHANE (CH4)	3.8508	16.0930	0.0002	0.0002	0.9989
4.C	Incineration and Open Burning of Waste	METHANE (CH4)	24.8989	44.5189	0.0002	0.0002	0.9991
3.C.3	Urea application	CARBON DIOXIDE (CO2)	71.8348	105.2201	0.0001	0.0002	0.9992
3.A.2	Manure Management	NITROUS OXIDE (N2O)	389.5684	523.5321	0.0001	0.0001	0.9994
4.B	Biological Treatment of Solid Waste	METHANE (CH4)	1.8973	8.9645	0.0001	0.0001	0.9995
2.D	Non-Energy Products from Fuels and Solvent Use	CARBON DIOXIDE (CO2)	6.3885	2.6520	0.0001	0.0001	0.9996
4.B	Biological Treatment of Solid Waste	NITROUS OXIDE (N2O)	1.0325	4.8784	0.0001	0.0001	0.9997
1.A.4	Other Sectors - Liquid Fuels	NITROUS OXIDE (N2O)	19.0723	23.6765	0.0000	0.0000	0.9998

Code	IPCC Category	Greenhouse gas	2012 Year Estimate Ex0 (Gg CO_2-eq)	2022 Year Estimate Ext (Gg CO_2-eq)	Trend Assessment (Txt)	% Contribution to Trend	Cumulative Total of Column G
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	NITROUS OXIDE (N2O)	0.7718	3.2844	0.0000	0.0000	0.9998
3.C.6	Indirect N2O Emissions from manure management	NITROUS OXIDE (N2O)	58.3306	81.4246	0.0000	0.0000	0.9998
4.C	Incineration and Open Burning of Waste	NITROUS OXIDE (N2O)	3.4990	6.2477	0.0000	0.0000	0.9999
1.A.1	Energy Industries - Liquid Fuels	CARBON DIOXIDE (CO2)	1.0473	0.0226	0.0000	0.0000	0.9999
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	METHANE (CH4)	0.4078	1.7463	0.0000	0.0000	0.9999
1.A.4	Other Sectors - Liquid Fuels	METHANE (CH4)	2.3955	4.3036	0.0000	0.0000	0.9999
1.A.4	Other Sectors - Biomass - gas	METHANE (CH4)	0.6059	1.4673	0.0000	0.0000	1.0000
1.A.3.a	Civil Aviation - Liquid Fuels	NITROUS OXIDE (N2O)	0.4364	1.1798	0.0000	0.0000	1.0000
1.A.3.e	Other Transportation - Liquid Fuels	METHANE (CH4)	0.3186	0.8461	0.0000	0.0000	1.0000
3.C.2	Liming	CARBON DIOXIDE (CO2)	0.1411	0.5306	0.0000	0.0000	1.0000
1.A.4	Other Sectors - Solid Fuels	NITROUS OXIDE (N2O)	0.4267	0.2437	0.0000	0.0000	1.0000
1.A.4	Other Sectors - Solid Fuels	METHANE (CH4)	0.3006	0.1716	0.0000	0.0000	1.0000
1.A.4	Other Sectors - Biomass - gas	NITROUS OXIDE (N2O)	0.1147	0.2777	0.0000	0.0000	1.0000
1.A.3.a	Civil Aviation - Liquid Fuels	METHANE (CH4)	0.0115	0.0312	0.0000	0.0000	1.0000
1.A.1	Energy Industries - Liquid Fuels	NITROUS OXIDE (N2O)	0.0022	0.0000	0.0000	0.0000	1.0000
1.A.1	Energy Industries - Liquid Fuels	METHANE (CH4)	0.0012	0.0000	0.0000	0.0000	1.0000

Code	IPCC Category	Greenhouse gas	2012 Year Estimate Ex0 (Gg CO_2-eq)	2022 Year Estimate Ext (Gg CO_2-eq)	Trend Assessment (Txt)	% Contribution to Trend	Cumulative Total of Column G
			28,072.2050	38,211.9624	0.8840	1	

Annex III.II Level Assessment

Code	IPCC Category	Greenhouse gas	2022 Ex,t (Gg CO_2-eq)	|Ex,t| (Gg CO_2-eq)	Lx,t	Cumulative Total of Column F
3.B.1.a	Forest land Remaining Forest land	CARBON DIOXIDE (CO2)	- 18,072.1001	18,072.1001	0.1987	0.1987
3.A.1	Enteric Fermentation	METHANE (CH4)	16,686.6350	16,686.6350	0.1835	0.3822
1.A.4	Other Sectors - Biomass - solid	METHANE (CH4)	10,645.4025	10,645.4025	0.1171	0.4992
3.B.5.a	Settlements Remaining Settlements	CARBON DIOXIDE (CO2)	- 8,256.5802	8,256.5802	0.0908	0.5900
3.B.2.a	Cropland Remaining Cropland	CARBON DIOXIDE (CO2)	6,345.5164	6,345.5164	0.0698	0.6598
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CARBON DIOXIDE (CO2)	5,437.1350	5,437.1350	0.0598	0.7196
2.A.1	Cement production	CARBON DIOXIDE (CO2)	4,792.2391	4,792.2391	0.0527	0.7723
1.A.3.b	Road Transportation - Liquid Fuels	CARBON DIOXIDE (CO2)	3,930.5052	3,930.5052	0.0432	0.8155
3.C.7	Rice cultivation	METHANE (CH4)	2,327.3374	2,327.3374	0.0256	0.8411
4.D	Wastewater Treatment and Discharge	METHANE (CH4)	1,924.1072	1,924.1072	0.0212	0.8622
1.A.4	Other Sectors - Liquid Fuels	CARBON DIOXIDE (CO2)	1,880.5799	1,880.5799	0.0207	0.8829

Code	IPCC Category	Greenhouse gas	2022 Ex,t (Gg CO_2 -eq)	|Ex,t| (Gg CO_2 -eq)	Lx,t	Cumulative Total of Column F
3.C.4	Direct N2O Emissions from managed soils	NITROUS OXIDE (N2O)	1,673.1809	1,673.1809	0.0184	0.9013
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CARBON DIOXIDE (CO2)	1,562.6890	1,562.6890	0.0172	0.9185
3.A.2	Manure Management	METHANE (CH4)	1,513.3330	1,513.3330	0.0166	0.9351
4.D	Wastewater Treatment and Discharge	NITROUS OXIDE (N2O)	1,382.8449	1,382.8449	0.0152	0.9503
4.A	Solid Waste Disposal	METHANE (CH4)	1,363.1061	1,363.1061	0.0150	0.9653
3.C.5	Indirect N2O Emissions from managed soils	NITROUS OXIDE (N2O)	682.5518	682.5518	0.0075	0.9728
1.A.3.e	Other Transportation - Liquid Fuels	CARBON DIOXIDE (CO2)	539.5417	539.5417	0.0059	0.9788
3.A.2	Manure Management	NITROUS OXIDE (N2O)	523.5321	523.5321	0.0056	0.9845
1.A.4	Other Sectors - Biomass - solid	NITROUS OXIDE (N2O)	498.1143	498.1143	0.0055	0.9900
1.A.3.a	Civil Aviation - Liquid Fuels	CARBON DIOXIDE (CO2)	159.1565	159.1565	0.0018	0.9917
3.C.3	Urea application	CARBON DIOXIDE (CO2)	105.2201	105.2201	0.0012	0.9929
3.C.6	Indirect N2O Emissions from manure management	NITROUS OXIDE (N2O)	81.4246	81.4246	0.0009	0.9938
4.C	Incineration and Open Burning of Waste	CARBON DIOXIDE (CO2)	79.6233	79.6233	0.0009	0.9948
1.A.4	Other Sectors - Solid Fuels	CARBON DIOXIDE (CO2)	57.9898	57.9898	0.0006	0.9953
1.A.3.e	Other Transportation - Liquid Fuels	NITROUS OXIDE (N2O)	55.1847	55.1847	0.0006	0.9959
1.A.2	Manufacturing Industries and Construction - Biomass - solid	NITROUS OXIDE (N2O)	53.7116	53.7116	0.0006	0.9965
1.A.3.b	Road Transportation - Liquid Fuels	NITROUS OXIDE (N2O)	52.3055	52.3055	0.0006	0.9971
4.C	Incineration and Open Burning of Waste	METHANE (CH4)	44.5189	44.5189	0.0005	0.9976

Code	IPCC Category	Greenhouse gas	2022 Ex,t (Gg CO_2 -eq)	|Ex,t| (Gg CO_2 -eq)	Lx,t	Cumulative Total of Column F
1.A.2	Manufacturing Industries and Construction - Biomass - solid	METHANE (CH4)	42.5639	42.5639	0.0005	0.9980
3.B.3.a	Grassland Remaining Grassland	CARBON DIOXIDE (CO2)	-38.7942	38.7942	0.0004	0.9985
1.A.4	Other Sectors - Liquid Fuels	NITROUS OXIDE (N2O)	23.6765	23.6765	0.0003	0.9987
1.A.3.b	Road Transportation - Liquid Fuels	METHANE (CH4)	23.2206	23.2206	0.0003	0.9990
1.A.2	Manufacturing Industries and Construction - Solid Fuels	NITROUS OXIDE (N2O)	22.8463	22.8463	0.0003	0.9992
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	16.7026	16.7026	0.0002	0.9994
1.A.2	Manufacturing Industries and Construction - Solid Fuels	METHANE (CH4)	16.0930	16.0930	0.0002	0.9996
4.B	Biological Treatment of Solid Waste	METHANE (CH4)	8.9645	8.9645	0.0001	0.9997
4.C	Incineration and Open Burning of Waste	NITROUS OXIDE (N2O)	6.2477	6.2477	0.0001	0.9998
4.B	Biological Treatment of Solid Waste	NITROUS OXIDE (N2O)	4.8784	4.8784	0.0001	0.9998
1.A.4	Other Sectors - Liquid Fuels	METHANE (CH4)	4.3036	4.3036	0.0000	0.9999
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	NITROUS OXIDE (N2O)	3.2844	3.2844	0.0000	0.9999
2.D	Non-Energy Products from Fuels and Solvent Use	CARBON DIOXIDE (CO2)	2.6520	2.6520	0.0000	0.9999
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	METHANE (CH4)	1.7463	1.7463	0.0000	0.9999
1.A.4	Other Sectors - Biomass - gas	METHANE (CH4)	1.4673	1.4673	0.0000	1.0000
1.A.3.a	Civil Aviation - Liquid Fuels	NITROUS OXIDE (N2O)	1.1798	1.1798	0.0000	1.0000
1.A.3.e	Other Transportation - Liquid Fuels	METHANE (CH4)	0.8461	0.8461	0.0000	1.0000
3.C.2	Liming	CARBON DIOXIDE (CO2)	0.5306	0.5306	0.0000	1.0000

Code	IPCC Category	Greenhouse gas	2022 Ex,t (Gg CO_2 -eq)	|Ex,t| (Gg CO_2 -eq)	Lx,t	Cumulative Total of Column F
1.A.4	Other Sectors - Biomass - gas	NITROUS OXIDE (N2O)	0.2777	0.2777	0.0000	1.0000
1.A.4	Other Sectors - Solid Fuels	NITROUS OXIDE (N2O)	0.2437	0.2437	0.0000	1.0000
1.A.4	Other Sectors - Solid Fuels	METHANE (CH4)	0.1716	0.1716	0.0000	1.0000
1.A.3.a	Civil Aviation - Liquid Fuels	METHANE (CH4)	0.0312	0.0312	0.0000	1.0000
1.A.1	Energy Industries - Liquid Fuels	CARBON DIOXIDE (CO2)	0.0226	0.0226	0.0000	1.0000
1.A.1	Energy Industries - Liquid Fuels	NITROUS OXIDE (N2O)	0.0000	0.0000	0.0000	1.0000
1.A.1	Energy Industries - Liquid Fuels	METHANE (CH4)	0.0000	0.0000	0.0000	1.0000
			38,211.9624	90,946.9114	1	

Annex IV. Uncertainties Analysis

Base year for assessment of uncertainty in trend: 2012, Year T: 2022						
A	B	C	D	E	F	G
2006 IPCC Categories	**Gas**	**Base Year emissions or removals (Gg CO_2 -eq)**	**Year T emissions or removals (Gg CO_2 -eq)**	**Activity Data Uncertainty (%)**	**Emission Factor Uncertainty (%)**	**Combined Uncertainty (%)**
1.A - Fuel Combustion Activities						
1.A.1.a.i - Electricity Generation - Liquid Fuels	CO_2	1.0473	0.0226	5.0000	2.5000	5.5902
1.A.1.a.i - Electricity Generation - Liquid Fuels	CH_4	0.0012	0.0000	5.0000	233.3000	233.3536
1.A.1.a.i - Electricity Generation - Liquid Fuels	N_2O	0.0022	0.0000	5.0000	233.3000	233.3536
1.A.2.a - Iron and Steel - Liquid Fuels	CO_2	87.8483	428.4402	5.0000	5.3000	7.2863
1.A.2.a - Iron and Steel - Liquid Fuels	CH_4	0.0992	0.4808	5.0000	233.3000	233.3536
1.A.2.a - Iron and Steel - Liquid Fuels	N_2O	0.1878	0.9063	5.0000	233.3000	233.3536
1.A.2.a - Iron and Steel - Solid Fuels	CO_2	83.0149	346.9291	5.0000	5.4000	7.3593
1.A.2.a - Iron and Steel - Solid Fuels	CH_4	0.2457	1.0269	5.0000	200.0000	200.0625
1.A.2.a - Iron and Steel - Solid Fuels	N_2O	0.3488	1.4578	5.0000	233.3000	233.3536
1.A.2.a - Iron and Steel - Biomass – solid	CH_4	0.0008	0.0045	50.0000	233.3000	238.5978
1.A.2.a - Iron and Steel - Biomass – solid	N_2O	0.0010	0.0057	50.0000	275.0000	279.5085
1.A.2.e - Food Processing, Beverages and Tobacco - Liquid Fuels	CO_2	77.4444	313.6586	5.0000	5.3400	7.3154
1.A.2.e - Food Processing, Beverages and Tobacco - Liquid Fuels	CH_4	0.0877	0.3446	5.0000	233.3300	233.3836
1.A.2.e - Food Processing, Beverages and Tobacco - Liquid Fuels	N_2O	0.1660	0.6460	5.0000	233.3300	233.3836
1.A.2.e - Food Processing, Beverages and Tobacco - Solid Fuels	CO_2	7.8850	32.9522	5.0000	5.3900	7.3520
1.A.2.e - Food Processing, Beverages and Tobacco - Solid Fuels	CH_4	0.0233	0.0975	5.0000	200.0000	200.0625

Base year for assessment of uncertainty in trend: 2012, Year T: 2022						
A	B	C	D	E	F	G
2006 IPCC Categories	**Gas**	**Base Year emissions or removals (Gg CO_2 -eq)**	**Year T emissions or removals (Gg CO_2 -eq)**	**Activity Data Uncertainty (%)**	**Emission Factor Uncertainty (%)**	**Combined Uncertainty (%)**
1.A.2.e - Food Processing, Beverages and Tobacco - Solid Fuels	N_2O	0.0331	0.1385	5.0000	233.3300	233.3836
1.A.2.e - Food Processing, Beverages and Tobacco - Biomass – solid	CH_4	1.6981	8.5068	50.0000	233.3300	238.6271
1.A.2.e - Food Processing, Beverages and Tobacco - Biomass – solid	N_2O	2.1429	10.7347	50.0000	275.0000	279.5085
1.A.2.f - Non-Metallic Minerals - Liquid Fuels	CO_2	27.2279	100.2958	5.0000	5.3400	7.3154
1.A.2.f - Non-Metallic Minerals - Liquid Fuels	CH_4	0.0309	0.1138	5.0000	233.3300	233.3836
1.A.2.f - Non-Metallic Minerals - Liquid Fuels	N_2O	0.0584	0.2152	5.0000	233.3300	233.3836
1.A.2.f - Non-Metallic Minerals - Solid Fuels	CO_2	1,087.1097	4,543.1603	5.0000	5.3900	7.3520
1.A.2.f - Non-Metallic Minerals - Solid Fuels	CH_4	3.2177	13.4470	5.0000	200.0000	200.0625
1.A.2.f - Non-Metallic Minerals - Solid Fuels	N_2O	4.5679	19.0899	5.0000	233.3300	233.3836
1.A.2.f - Non-Metallic Minerals - Biomass - solid	CH_4	0.9013	4.7949	50.0000	233.3300	238.6271
1.A.2.f - Non-Metallic Minerals - Biomass - solid	N_2O	1.1374	6.0508	50.0000	275.0000	279.5085
1.A.2.j - Wood and wood products - Liquid Fuels	CO_2	25.7510	98.6063	5.0000	5.3400	7.3154
1.A.2.j - Wood and wood products - Liquid Fuels	CH_4	0.0292	0.1108	5.0000	233.3300	233.3836
1.A.2.j - Wood and wood products - Liquid Fuels	N_2O	0.0553	0.2088	5.0000	233.3300	233.3836
1.A.2.j - Wood and wood products - Biomass - solid	CH_4	3.6506	18.9341	50.0000	233.3300	238.6271
1.A.2.j - Wood and wood products - Biomass - solid	N_2O	4.6068	23.8931	50.0000	275.0000	279.5085
1.A.2.l - Textile and Leather - Liquid Fuels	CO_2	43.5727	157.1233	5.0000	5.3400	7.3154
1.A.2.l - Textile and Leather - Liquid Fuels	CH_4	0.0494	0.1770	5.0000	233.3300	233.3836
1.A.2.l - Textile and Leather - Liquid Fuels	N_2O	0.0935	0.3342	5.0000	233.3300	233.3836
1.A.2.l - Textile and Leather - Biomass - solid	CH_4	1.7800	7.2897	50.0000	233.3300	238.6271

Base year for assessment of uncertainty in trend: 2012, Year T: 2022						
A	B	C	D	E	F	G
2006 IPCC Categories	**Gas**	**Base Year emissions or removals (Gg CO_2 -eq)**	**Year T emissions or removals (Gg CO_2 -eq)**	**Activity Data Uncertainty (%)**	**Emission Factor Uncertainty (%)**	**Combined Uncertainty (%)**
1.A.2.l - Textile and Leather - Biomass - solid	N_2O	2.2462	9.1990	50.0000	275.0000	279.5085
1.A.4.a - Commercial/Institutional - Liquid Fuels	CO_2	211.5340	294.6054	5.0000	5.3400	7.3154
1.A.4.a - Commercial/Institutional - Liquid Fuels	CH_4	0.5051	0.6614	5.0000	200.0000	200.0625
1.A.4.a - Commercial/Institutional - Liquid Fuels	N_2O	0.1271	0.1320	5.0000	233.3300	233.3836
1.A.4.a - Commercial/Institutional - Solid Fuels	CO_2	101.5436	57.9898	5.0000	5.3900	7.3520
1.A.4.a - Commercial/Institutional - Solid Fuels	CH_4	0.3006	0.1716	5.0000	200.0000	200.0625
1.A.4.a - Commercial/Institutional - Solid Fuels	N_2O	0.4267	0.2437	5.0000	233.3300	233.3836
1.A.4.a - Commercial/Institutional - Biomass - solid	CH_4	60.2003	166.1771	50.0000	200.0000	206.1553
1.A.4.a - Commercial/Institutional - Biomass - solid	N_2O	7.5967	20.9700	50.0000	275.0000	279.5085
1.A.4.b - Residential - Liquid Fuels	CO_2	442.4469	1,205.1351	5.0000	3.9600	6.3782
1.A.4.b - Residential - Liquid Fuels	CH_4	1.1203	2.6920	5.0000	200.0000	200.0625
1.A.4.b - Residential - Liquid Fuels	N_2O	0.3340	0.5256	5.0000	233.3300	233.3836
1.A.4.b - Residential - Biomass – solid	CH_4	8,758.9662	10,479.2254	50.0000	200.0000	206.1553
1.A.4.b - Residential - Biomass – solid	N_2O	431.7285	477.1443	50.0000	275.0000	279.5085
1.A.4.b - Residential - Biomass – gas	CH_4	0.6059	1.4673	5.0000	200.0000	200.0625
1.A.4.b - Residential - Biomass – gas	N_2O	0.1147	0.2777	5.0000	200.0000	200.0625
1.A.4.c.i - Stationary - Liquid Fuels	CO_2	129.1226	159.1283	5.0000	5.3400	7.3154
1.A.4.c.i - Stationary - Liquid Fuels	CH_4	0.4890	0.6025	5.0000	233.3300	233.3836
1.A.4.c.i - Stationary - Liquid Fuels	N_2O	0.2777	0.3422	5.0000	233.3300	233.3836
1.A.2.m - Non-specified Industry - Liquid Fuels	CO_2	98.0443	464.5649	5.0000	5.3400	7.3154
1.A.2.m - Non-specified Industry - Liquid Fuels	CH_4	0.1113	0.5193	5.0000	233.3300	233.3836
1.A.2.m - Non-specified Industry - Liquid Fuels	N_2O	0.2108	0.9738	5.0000	233.3300	233.3836
1.A.2.m - Non-specified Industry - Solid Fuels	CO_2	123.0148	514.0934	5.0000	5.3900	7.3520

Base year for assessment of uncertainty in trend: 2012, Year T: 2022						
A	B	C	D	E	F	G
2006 IPCC Categories	**Gas**	**Base Year emissions or removals (Gg CO_2 -eq)**	**Year T emissions or removals (Gg CO_2 -eq)**	**Activity Data Uncertainty (%)**	**Emission Factor Uncertainty (%)**	**Combined Uncertainty (%)**
1.A.2.m - Non-specified Industry - Solid Fuels	CH_4	0.3641	1.5216	5.0000	200.0000	200.0625
1.A.2.m - Non-specified Industry - Solid Fuels	N_2O	0.5169	2.1602	5.0000	233.3300	233.3836
1.A.2.m - Non-specified Industry - Biomass - solid	CH_4	0.6138	3.0338	50.0000	233.3300	238.6271
1.A.2.m - Non-specified Industry - Biomass - solid	N_2O	0.7746	3.8284	50.0000	275.0000	279.5085
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	CO_2	219.0568	230.8299	5.0000	4.0600	6.4408
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	CH_4	0.0429	0.0452	5.0000	-	5.0000
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	N_2O	1.6238	1.7110	5.0000	-	5.0000
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CO_2	58.8789	159.1565	5.0000	4.0600	6.4408
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CH_4	0.0115	0.0312	5.0000	-	5.0000
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	N_2O	0.4364	1.1798	5.0000	-	5.0000
1.A.3.b.i - Cars - Liquid Fuels	CO_2	227.7713	675.1954	5.0000	5.3400	7.3154
1.A.3.b.i - Cars - Liquid Fuels	CH_4	2.5583	6.1631	5.0000	233.3300	233.3836
1.A.3.b.i - Cars - Liquid Fuels	N_2O	2.7265	8.6709	5.0000	243.7500	243.8013
1.A.3.b.ii - Light-duty trucks - Liquid Fuels	CO_2	8.6771	224.3422	5.0000	5.3400	7.3154
1.A.3.b.ii - Light-duty trucks - Liquid Fuels	CH_4	0.0128	0.3306	5.0000	233.3300	233.3836
1.A.3.b.ii - Light-duty trucks - Liquid Fuels	N_2O	0.1210	3.1290	5.0000	243.7500	243.8013
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fuels	CO_2	918.3572	1,997.1968	5.0000	5.3400	7.3154
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fuels	CH_4	1.3534	2.9432	5.0000	233.3300	233.3836
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fuels	N_2O	12.8087	27.8556	5.0000	243.7500	243.8013
1.A.3.b.iv - Motorcycles - Liquid Fuels	CO_2	294.6844	1,033.7709	5.0000	5.3400	7.3154

Base year for assessment of uncertainty in trend: 2012, Year T: 2022						
A	B	C	D	E	F	G
2006 IPCC Categories	**Gas**	**Base Year emissions or removals (Gg CO_2 -eq)**	**Year T emissions or removals (Gg CO_2 -eq)**	**Activity Data Uncertainty (%)**	**Emission Factor Uncertainty (%)**	**Combined Uncertainty (%)**
1.A.3.b.iv - Motorcycles - Liquid Fuels	CH_4	3.9291	13.7836	5.0000	233.3300	233.3836
1.A.3.b.iv - Motorcycles - Liquid Fuels	N_2O	3.6060	12.6499	5.0000	243.7500	243.8013
1.A.3.e.ii - Off-road - Liquid Fuels	CO_2	203.1501	539.5417	5.0000	5.3400	7.3154
1.A.3.e.ii - Off-road - Liquid Fuels	CH_4	0.3186	0.8461	5.0000	233.3300	233.3836
1.A.3.e.ii - Off-road - Liquid Fuels	N_2O	20.7783	55.1847	5.0000	243.7500	243.8013
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	CO_2	179.2467	221.7111	5.0000	5.3400	7.3154
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	CH_4	0.2811	0.3477	5.0000	233.3300	233.3836
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	N_2O	18.3335	22.6768	5.0000	233.3300	233.3836
2.A - Mineral Industry						
2.A.1 - Cement production	CO_2	470.7781	6,881.8101	78.8984	4.5000	79.0266
2.D - Non-Energy Products from Fuels and Solvent Use						
2.D.1 - Lubricant Use	CO_2	4.2445	1.8996	20.0000	50.0900	53.9352
2.D.2 - Paraffin Wax Use	CO_2	2.1440	0.7524	20.0000	100.1200	102.0981
2.F - Product Uses as Substitutes for Ozone Depleting Substances						
2.F.1.a - Refrigeration and Stationary Air Conditioning	CH_2FCF_3	-	16.7026	5.0000	-	5.0000
3.A – Livestock						
3.A.1.a.i - Dairy Cows	CH_4	1,622.3159	1,986.2511	20.0000	50.0000	53.8516
3.A.1.a.ii - Other Cattle	CH_4	4,721.9616	4,679.7428	20.0000	50.0000	53.8516
3.A.1.b – Buffalo	CH_4	7,905.0341	7,904.7137	20.0000	50.0000	53.8516

Base year for assessment of uncertainty in trend: 2012, Year T: 2022						
A	B	C	D	E	F	G
2006 IPCC Categories	**Gas**	**Base Year emissions or removals (Gg CO_2 -eq)**	**Year T emissions or removals (Gg CO_2 -eq)**	**Activity Data Uncertainty (%)**	**Emission Factor Uncertainty (%)**	**Combined Uncertainty (%)**
3.A.1.c – Sheep	CH_4	113.0174	107.9687	20.0000	50.0000	53.8516
3.A.1.d – Goats	CH_4	1,331.8141	1,958.6984	20.0000	50.0000	53.8516
3.A.1.f – Horses	CH_4	9.0080	5.5410	20.0000	50.0000	53.8516
3.A.1.g - Mules and Asses	CH_4	1.5296	1.5898	20.0000	50.0000	53.8516
3.A.1.h – Swine	CH_4	31.8497	42.1295	20.0000	50.0000	53.8516
3.A.2.a.i - Dairy cows	CH_4	139.8548	171.2285	20.0000	30.0000	36.0555
3.A.2.a.i - Dairy cows	N_2O	1.3738	1.6819	20.0000	111.8000	113.5748
3.A.2.a.ii - Other cattle	CH_4	349.7749	346.6476	20.0000	30.0000	36.0555
3.A.2.a.ii - Other cattle	N_2O	30.1804	29.9105	20.0000	111.8000	113.5748
3.A.2.b – Buffalo	CH_4	718.6395	718.6103	20.0000	30.0000	36.0555
3.A.2.b – Buffalo	N_2O	58.9221	58.9197	20.0000	111.8000	113.5748
3.A.2.c – Sheep	CH_4	3.3905	3.2391	20.0000	30.0000	36.0555
3.A.2.c – Sheep	N_2O	10.0493	9.6004	20.0000	111.8000	113.5748
3.A.2.d – Goats	CH_4	45.2817	66.5957	20.0000	30.0000	36.0555
3.A.2.d – Goats	N_2O	267.4258	393.3030	20.0000	111.8000	113.5748
3.A.2.f – Horses	CH_4	0.8207	0.5048	20.0000	30.0000	36.0555
3.A.2.f – Horses	N_2O	1.3384	0.8233	20.0000	111.8000	113.5748
3.A.2.g - Mules and Asses	CH_4	0.1377	0.1431	20.0000	30.0000	36.0555
3.A.2.g - Mules and Asses	N_2O	0.2234	0.2322	20.0000	111.8000	113.5748
3.A.2.h – Swine	CH_4	127.3988	168.5179	20.0000	30.0000	36.0555
3.A.2.h – Swine	N_2O	9.1980	12.1667	20.0000	111.8000	113.5748
3.A.2.i – Poultry	CH_4	25.5069	37.7491	20.0000	30.0000	36.0555
3.A.2.i – Poultry	N_2O	10.2608	15.1910	20.0000	111.8000	113.5748

Base year for assessment of uncertainty in trend: 2012, Year T: 2022						
A	B	C	D	E	F	G
2006 IPCC Categories	**Gas**	**Base Year emissions or removals (Gg CO_2 -eq)**	**Year T emissions or removals (Gg CO_2 -eq)**	**Activity Data Uncertainty (%)**	**Emission Factor Uncertainty (%)**	**Combined Uncertainty (%)**
3.A.2.j - Other (please specify)	CH_4	0.0339	0.0968	20.0000	30.0000	36.0555
3.A.2.j - Other (please specify)	N_2O	0.5964	1.7034	20.0000	111.8000	113.5748
3.B – Land						
3.B.1.a - Forest land Remaining Forest land	CO_2	-13,220.3291	-18,072.1001	90.0000	50.0000	102.9563
3.B.2.a - Cropland Remaining Cropland	CO_2	1,346.6755	6,345.5164	50.9900	75.0000	90.6917
3.B.3.a - Grassland Remaining Grassland	CO_2	2,346.2852	- 38.7942	100.0000	6.0000	100.1798
3.B.5.a - Settlements Remaining Settlements	CO_2	-143.5428	- 8,256.5802	50.0000	-	50.0000
3.C.2 – Liming	CO_2	0.1411	0.5306	20.0000	50.0000	53.8516
3.C.3 - Urea application	CO_2	71.8348	105.2201	5.0000	50.0000	50.2494
3.C.4 - Direct N2O Emissions from managed soils	N_2O	1,435.6056	1,673.1809	35.0000	428.3448	429.7724
3.C.5 - Indirect N2O Emissions from managed soils	N_2O	565.9892	682.5518	28.2843	514.5092	515.2860
3.C.6 - Indirect N2O Emissions from manure management	N_2O	58.3306	81.4246	53.8500	400.0000	403.6085
3.C.7 - Rice cultivation	CH_4	2,412.5856	2,327.3374	11.0200	178.6000	178.9397
4.A - Solid Waste Disposal						
4.A.1 - Managed Waste Disposal Sites	CH_4	10.9149	1.4906	100.0000	-	100.0000
4.A.2 - Unmanaged Waste Disposal Sites	CH_4	167.0408	858.9447	100.0000	-	100.0000
4.A.3 - Uncategorised Waste Disposal Sites	CH_4	85.0054	502.6709	100.0000	-	100.0000
4.B - Biological Treatment of Solid Waste						
4.B - Biological Treatment of Solid Waste	CH_4	1.8973	8.9645	100.0000	100.0000	141.4214
4.B - Biological Treatment of Solid Waste	N_2O	1.0325	4.8784	100.0000	150.0000	180.2776
4.C - Incineration and Open Burning of Waste						
4.C.1 - Waste Incineration	CO_2	0.4462	0.5663	50.0000	40.0000	64.0312
4.C.1 - Waste Incineration	CH_4	0.0013	0.0017	50.0000	100.0000	111.8034

Base year for assessment of uncertainty in trend: 2012, Year T: 2022						
A	B	C	D	E	F	G
2006 IPCC Categories	**Gas**	**Base Year emissions or removals (Gg CO_2 -eq)**	**Year T emissions or removals (Gg CO_2 -eq)**	**Activity Data Uncertainty (%)**	**Emission Factor Uncertainty (%)**	**Combined Uncertainty (%)**
4.C.1 - Waste Incineration	N_2O	0.0116	0.0147	50.0000	100.0000	111.8034
4.C.2 - Open Burning of Waste	CO_2	44.2493	79.0570	50.0000	40.0000	64.0312
4.C.2 - Open Burning of Waste	CH_4	24.8976	44.5172	50.0000	100.0000	111.8034
4.C.2 - Open Burning of Waste	N_2O	3.4874	6.2330	50.0000	100.0000	111.8034
4.D - Wastewater Treatment and Discharge						
4.D.1 - Domestic Wastewater Treatment and Discharge	CH_4	126.2118	572.4399	42.4264	42.4264	60.0000
4.D.1 - Domestic Wastewater Treatment and Discharge	N_2O	324.4774	1,382.8439	34.6410	51.9615	62.4500
4.D.2 - Industrial Wastewater Treatment and Discharge	CH_4	597.3545	1,351.6673	141.4214	42.4264	147.6482
4.D.2 - Industrial Wastewater Treatment and Discharge	N_2O	0.0011	0.0011	20.0000	30.0000	36.0555
		Sum(C): 28,292.928	**Sum(D): 40,534.120**			**Sum(H): 6,142.035**
					Uncertainty in total inventory:	**78.371**

Annex V. Energy Sector

Annex V.I Fuels and its alias name in Nepalese Context

IPCC 2006	Nepal
Motor Gasoline	Petrol
Jet Kerosene	Aviation Turbine Fuel
Other Kerosene	Kerosene
Gas/Diesel Oil	Diesel
Residual Fuel Oil	Furnace Oil or Fuel Oil
Liquefied Petroleum Gases	Liquefied Petroleum Gases (LPG)
Wood/Wood Waste	Fuelwood

Annex V.II Energy Supply Data

- **Petroleum Sales**

Source: Nepal Oil Corporation

Fiscal Year	Petrol	Diesel	Kerosene	ATF	Diesel	Furnace	LPG
Unit	kL	kL	kL	kL	kL	kL	MT
1993	34,983	226,622	180,900	37,524	3,794	32,003	13,049
1994	41,193	250,500	208,715	40,619	4,449	18,293	18,600
1995	44,709	257,910	243,810	47,864	1,983	17,296	21,824
1996	46,939	300,604	282,026	51,412	967	27,776	22,961
1997	49,994	315,780	294,982	55,549	547	33,860	25,019
1998	55,585	310,569	331,120	56,849	3,989	26,811	30,627
1999	59,245	326,060	316,381	63,131	3,416	20,934	40,102
2000	63,271	286,233	386,592	47,453	2,413	18,255	48,757
2001	67,457	299,973	348,620	52,839	610	14,496	56,079
2002	63,271	286,233	386,592	47,453	2,413	18,255	48,757
2003	67,457	299,973	348,620	52,839	610	14,496	56,079
2004	67,586	299,730	310,826	64,041	577	12,653	66,142
2005	75,989	315,368	239,328	66,825	88	2,696	77,594
2006	80,989	294,329	226,637	64,335	290	3,695	81,005
2007	101,912	306,687	197,850	63,778	179	4,558	93,562
2008	100,842	302,706	155,216	68,938	306	2,919	96,837
2009	124,169	446,468	70,089	68,935	377	2,171	115,813
2010	162,275	612,505	55,788	82,631	238	2,589	141,171
2011	187,641	655,128	49,495	101,314	227	1,415	159,286
2012	199,749	648,513	41,808	109,808	-	435	181,411
2013	221,676	716,747	24,721	115,786	258	2,450	207,038
2014	251,451	811,100	19,064	123,527	-	2,172	232,660
2015	283,567	901,393	18,628	139,404	-	883	258,299
2016	238,578	782,451	14,858	80,119	-	77	214,194
2017	402,278	1,297,066	19,459	164,299	-	36	312,928

2018	484,781	1,597,551	22,311	194,358	-	-	370,560
2019	562,866	1,702,157	25,086	200,137	-	-	429,609
2020	507,786	1,453,592	19,212	138,680	-	-	449,063
2021	587,677	1,698,427	23,427	70,400	-	-	477,752
2022	730,488	1,727,571	17,817	154,078	-	-	536,028

(NOC, 2024)

- **Coal production and import**

Year	**Primary Production**	**Import**	**Year**	**Primary Production**	**Import**
	Kilo tonnes	**Kilo tonnes**		**Kilo tonnes**	**Kilo tonnes**
1994	NA	NA	**2011**	13.16	476.25
1995	NA	NA	**2012**	9.41	355.77
1996	NA	NA	**2013**	14.08	443.32
1997	NA	NA	**2014**	8.20	459.00
1998	NA	NA	**2015**	6.80	794.00
1999	10.95	104.22	**2016**	1.70	762.00
2000	17.53	400.62	**2017**	8.20	992.00
2001	16.59	279.84	**2018**	11.80	1,302.00
2002	9.61	248.39	**2019**	-	1,667.61
2003	11.85	215.91	**2020**	7.00	1,340.19
2004	10.46	279.84	**2021**	11.30	1,911.81
2005	9.29	247.88	**2022**	6.93	1,781.22
2006	11.96	400.62			
2007	19.58	239.48			
2008	14.02	314.12			
2009	14.82	293.76			
2010	11.80	473.15			

(NSO, 2024)

NA: Not available

Note: For periods of missing data, it is assumed that the total supply is as per the total demand.

Annex V.III Energy Consumption data (Energy Balances)

2012							
In Terajoules							
	Residential	industrial	transportation	commercial	agriculture	other	total
Fuelwood	253,162	7,087	-	7,167	-	-	267,415
Agri residue	13,226	-	-	-	-	-	13,226
Animal waste	19,112	-	-	-	-	-	19,112
Other biomass	339	-	-	-	-	-	339
Agri biomass	13,565	-	-	-	-	-	13,565
Total Traditional	285,839	7,087	-	7,167	-	-	300,092
Biogas	4,328	-	-	-	-	-	4,328
Bio briquette	36	-	-	-	-	-	36
Dec electricity	293	-	-	-	-	-	293
Grid Electricity	4,824	4,046	23	1,284	233	146	10,556
Electricity total	5,117	4,046	23	1,284	233	146	10,849
Solar	1	-	-	-	-	-	1
Total Renewable	295,320	11,133	23	8,451	233	146	315,306
LPG	5,701	-	220	3,014	-	-	8,934
Kerosene	1,150	68	-	297	-	-	1,516
Motor spirit	-	89	6,517	12	63	-	6,681
ATF	-	-	3,972	-	-	-	3,972
Diesel	-	4,462	16,021	12	4,103	-	24,598
Furnace Oil	-	18	-	-	-	-	18
Other petroleum	212	216	7	-	-	-	435
Coal/coke	-	13,753	-	1,073	-	-	14,826
Total Commercial	7,063	18,607	26,729	4,415	4,166	-	60,981
Battery	2	-	-	-	-	-	2

Grand Total	302,385	29,740	26,753	12,866	4,398	146	376,288

(WECS, 2013)

2019							
In Terajoules							
	Agriculture	Commercial	Industry	Residential	Transport	Construction and mining	Total
Fuelwood	-	22,456	19,907	322,597	-	129	365,089
Agricultural residue	-	-	10,837	7,208	-	-	18,045
Animal waste	-	-	-	18,841	-	-	18,841
Total	-	22,456	30,744	348,646	-	129	401,975
Kerosene	-	-	303	176	-	411	890
Petrol	128	35	241	-	18,270	61	18,735
Diesel	8,417	37	14,449	-	36,141	4,561	63,605
ATF	-	-	-	-	6,306	-	6,306
LPG	-	9,169	2	10,390	-	45	19,606
Furnace	-	-	1,222	-	-	-	1,222
Total	8,546	9,240	16,216	10,566	60,717	5,079	110,364
Coal	-	3,266	37,514	-	-	-	40,780
Electricity	560	3,453	9,756	9,075	16	4	22,864
Total	9,106	15,959	63,486	19,641	60,733	5,083	174,008
Biogas	-	40	-	8,135	-	-	8,175
Solar	7	2,183	-	1,890	-	-	4,080
Wind	-	-	-	1	-	-	1
Micro/Pico	-	-	-	326	-	-	326
Total	7	2,223	-	10,352	-	-	12,582
Grand Total	9,113	40,638	94,230	378,639	60,733	5,212	588,565

(WECS, 2022b)

2020							
In Terajoules							
	Agriculture	Commercial	Industry	Residential	Transport	Construction and mining	Total
Fuelwood	-	21,638	18,263	326,863	-	84	366,847
Agricultural residue	-	-	10,975	7,279	-	-	18,254
Animal waste	-	-	-	17,878	-	-	17,878
Total	-	21,638	29,238	352,019	-	84	402,980
Kerosene	-	-	218	167	-	296	682
Petrol	133	34	223	-	14,035	48	14,473
Diesel	8,713	36	9,454	-	19,917	2,985	41,104
ATF	-	-	-	-	4,370	-	4,370
LPG	-	9,584	2	10,861	-	47	20,493
Furnace oil	-	-	374	-	-	-	374
Total	8,846	9,654	10,271	11,027	38,322	3,376	81,496
Coal	-	3,153	40,050	-	-	-	43,203
Electricity	597	3,418	9,194	9,977	10	4	23,200
Total	9,443	16,225	59,515	21,005	38,332	3,380	147,899
Biogas	-	45	-	10,096	-	-	10,141
Solar	19	2,166	-	1,896	-	-	4,080
Wind	-	-	-	1	-	-	1
Micro/Pico	-	-	-	436	-	-	436
Total	19	2,210	-	12,429	-	-	14,658
Grand Total	9,462	40,073	88,753	385,453	38,332	3,464	565,537

(WECS, 2022b)

2021							
In Terajoules							
	Agriculture	Commercial	Industry	Residential	Transport	Construction and mining	Total
Fuelwood	-	22,964	19,274	335,421	-	132	377,790
Agricultural residue	-	-	11,432	7,350	-	-	18,782
Animal waste	-	-	-	17,967	-	-	17,967
Total	-	22,964	30,706	360,738	-	132	414,540
Kerosene	-	-	278	176	-	377	831
Petrol	136	36	231	-	19,093	65	19,561
Diesel	8,943	37	14,597	-	35,280	4,608	63,465
ATF	-	-	-	-	2,218	-	2,218
LPG	-	10,848	2	10,900	-	53	21,803
Furnace	-	-	3,399	-	-	-	3,399
Total	9,079	10,920	18,508	11,076	56,592	5,103	111,277
Coal	-	3,295	55,150	-	-	-	58,446
Electricity	730	3,800	10,164	11,668	7	5	26,373
Total	9,809	18,015	83,821	22,744	56,599	5,109	196,096
Biogas	-	52	-	9,705	-	-	9,757
Solar	25	2,724	-	2,011	-	-	4,760
Wind	-	-	-	2	-	-	2
Micro/Pico	-	-	-	515	-	-	515
Total	25	2,775	-	12,233	-	-	15,033
Grand Total	9,834	43,755	114,527	395,715	56,599	5,240	625,670

(WECS, 2022b)

2022							
In Terajoules							
	Residential	Industrial	Commercial	Agriculture	Transportation	Construction and Mining	Total
Fuelwood	316,281	39,217	18,953			112	374,563
Agricultural residue	6,247	11,455	264				17,965
Animal waste	17,584	-	566				18,150
Total	340,111	50,672	19,783			112	410,679
Petrol		2,813	197	69	21,202	372	24,654
Diesel		15,476		5,075	40,494	5,035	66,080
Kerosene	151	402	64			24	641
LPG	18,927	796	4,596		1	336	24,656
ATF					5,393		5,393
Furnace		1,833				1	1,834
Total	19,078	21,320	4,857	5,144	67,090	5,769	123,258
Coal	60	57,475	613				58,148
Electricity	15,458	12,396	2,357	868	14	673	31,766
Total	34,595	91,191	7,828	6,012	67,104	6,442	213,172
Biogas	10,480		8				10,489
Wind	2		0				2
Micro/Pico	432		108				540
Solar	2,150		2,908	25			5,083
Total	13,064		3,024	25			16,114
Grand Total	387,771	141,863	30,635	6,037	67,104	6,554	639,965

(WECS, 2023)

Annex V.IV Energy Consumption by Fuel Categories (Year 2013 to 2018)

In Terajoules						
	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Traditional Total	335,656	376,100	381,166	386,316	390,187	396,616
Firewood	299,482	341,392	345,997	350,686	354,178	360,232
Agri residue	14,779	16,873	17,082	17,333	17,505	17,794
Animal Waste	21,395	17,836	18,087	18,338	18,504	18,589
Commercial total	77,623	82,018	97,613	94,128	136,179	155,536
Coal	17,375	13,398	19,469	22,452	27,799	31,898
Petroleum Products	49,488	52,921	61,511	53,398	87,420	99,998
Electricity	10,760	15,699	16,633	17,859	20,960	23,640
Renewable Energy	6,950	12,184	12,230	12,246	12,309	12,406
Grand Total	420,229	470,302	491,009	492,690	538,675	564,544

(MoF, 2019b)

Annex V.V Electricity Generation by Thermal Plants

	Generation			**Generation**	
	MWh			**MWh**	
	Hetauda thermal plant	**Duhabi multifuel plant**		**Hetauda thermal plant**	**Duhabi multifuel plant**
1987	28.62		**2006**	3,520.76	12,588.02
1988	98.90		**2007**	3,021.17	10,292.90
1989	8,716.20		**2008**	1,308.72	7,866.39
1990	130.70		**2009**	3,734.37	5,322.37
1991	202.30	268.20	**2010**	3,416.86	9,702.65
1992	11,002.70	20,249.43	**2011**	1,332.98	2,348.86
1993	11,132.50	36,321.13	**2012**	617.89	932.79
1994	4,848.20	56,662.34	**2013**	8,868.62	9,954.28
1995	3,876.00	76,266.10	**2014**	4,768.92	4,981.43
1996	7,686.50	28,634.10	**2015**	1,254.55	0
1997	9,366.30	29,347.55	**2016**	122.09	22.66
1998	18,681.80	85,663.67	**2017**	325.99	15.78
1999	24,203.64	86,215.07	**2018**	127.19	0
2000	11,065.64	53,317.61	**2019**	115.75	0
2001	5,197.05	19,310.18	**2020**	57.09	2.52
2002	3,045.05	13,652.54	**2021**	54.36	0.00
2003	269.30	4,149.17	**2022**	32.51	0
2004	1,119.35	8,742.88	**2023**	13.08	0
2005	2,192.82	11,142.48			

(NEA-GD, 2023, 2020)

Annex V.VI Industrial Classification

		IPCC-2006 ISIC-1989	ISIC-2008, NSIC-2019
1 A 2 a	Iron and Steel	ISIC Group 271 and Class 2731.	Group 241, Class 2431
1 A 2 b	Non-Ferrous Metals	ISIC Group 272 and Class 2732.	Group 242, Class 2432
1 A 2 c	Chemicals	ISIC Division 24.	Division 20, Division 21,
1 A 2 d	Pulp, Paper and Print	ISIC Divisions 21 and 22.	Division 17, Division 18,
1 A 2 e	Food Processing, Beverages and Tobacco	ISIC Divisions 15 and 16.	Division 10, Division 11, Division 12,
1 A 2 f	Non-Metallic Minerals	Includes products such as glass ceramic, cement, etc. ISIC Division 26.	Division 23,
1 A 2 g	Transport Equipment	ISIC Divisions 34 and 35.	Division 29, Division 30,
1 A 2 h	Machinery	Includes fabricated metal products, machinery, and equipment other than transport equipment. ISIC Divisions 28, 29, 30, 31 and 32.	Division 25, Division 28, Division 27,
1 A 2 i	Mining (excluding fuels) and Quarrying	ISIC Divisions 13 and 14.	Division 7, Division 8, Division 9,
1 A 2 j	Wood and Wood Products	ISIC Division 20.	Division 16,
1 A 2 k	Construction	ISIC Division 45.	Division 41, Division 42, Division 43,
1 A 2 l	Textile and Leather	ISIC Divisions 17, 18 and 19.	Division 13, Division 14, Division 15,
1 A 2 m	Non-specified Industry:	Any manufacturing industry/construction not included above or for which separate data are not available. Includes ISIC Divisions 25, 33, 36 and 37.	Division 22, Division 26, Division 32, Division 31, Division 33,

Annex V.VII Number of Vehicles registered

Year	Bus	Minibus/minitruck	Crane/dozer/Excavator/Truck	Car/Jeep/Van	Pickup	Micro bus	Tempo	Motorcycle	Tractor/Power Tiller	E-rickshaw	Other
1990	3,978	2,064	6,532	21,350	-	-	2,359	34,576	5,417	-	102
1991	458	437	834	2,353	-	-	856	5,697	965	-	1,549
1992	531	455	1,524	2,637	-	-	1,207	9,336	1,342	-	435
1993	606	185	1,491	2,266	-	-	62	8,513	751	-	381
1994	1,168	121	1,740	3,049	-	-	213	10,550	1,396	-	372
1995	850	83	1,629	3,043	-	-	241	11,401	1,814	-	353
1996	486	82	1,151	3,974	-	-	117	12,357	2,183	-	58
1997	608	175	907	4,521	-	-	185	15,739	1,278	-	352
1998	899	130	1,291	4,139	-	-	344	12,306	1,265	-	51
1999	872	19	978	2,507	-	-	388	17,090	2,248	-	37
2000	494	122	829	3,647	-	-	789	19,755	2,542	-	102
2001	1,203	250	1,271	5,152	-	-	232	29,291	3,519	-	77
2002	868	475	1,798	4,379	-	-	248	36,117	3,189	-	86
2003	432	298	1,212	2,906	581	232	17	29,404	2,485	-	43
2004	732	237	1,477	7,079	478	884	16	26,547	2,191	-	58
2005	753	285	1,592	4,781	-	584	48	31,273	1,374	-	21
2006	1,528	663	2,263	5,114	36	66	60	44,610	635	-	54,975
2007	1,564	806	3,278	5,156	736	138	12	72,568	2,942	-	1,535
2008	1,419	1,179	3,594	4,741	1,588	31	18	68,667	3,297	-	206
2009	1,843	593	3,643	6,857	1,287	128	20	83,334	4,663	-	202
2010	1,888	780	4,524	12,268	1,975	145	9	168,707	11,460	-	31
2011	1,610	1,370	1,969	8,510	3,087	115	2	138,907	7,937	-	133

Year	Bus	Minibus/minitruck	Crane/dozer/ Excavator/ Truck	Car/Jeep/Van	Pickup	Micro bus	Tempo	Motorcycle	Tractor/Power Tiller	E-rickshaw	Other
2012	2,085	1,170	1,333	8,711	2,981	155	10	145,135	8,413	-	91
2013	3,263	1,328	3,332	9,595	5,422	158	57	175,381	9,795	-	152
2014	2,776	1,412	2,789	11,372	5,668	178	17	163,945	10,070	-	116
2015	3,737	2,270	4,236	13,560	6,057	932	1,541	196,383	10,524	-	343
2016	4,353	4,625	8,328	28,361	5,060	1,137	2,613	267,439	9,786	11,894	169
2017	5,342	2,008	12,712	21,292	10,675	841	17,782	354,071	17,085	2,247	204
2018	2,972	1,973	12,154	24,338	10,342	1,934	16,209	341,623	13,396	12,325	348
2019	3,722	2,409	13,425	23,019	9,759	2,330	11,025	282,997	12,220	8,952	380
2020	2,282	998	4,112	11,211	4,347	393	5,764	209,671	5,160	1,068	216
2021	3,400	3,078	6,339	19,140	9,317	563	14,944	556,819	11,549	3,512	678
2022	3,679	2,160	8,235	21,242	8,598	485	10,132	503,279	8,872	8,767	134

(DoTM, 2019; MoF, 2024)

Annex V.VIII Detailed Methodologies for Energy sector

Energy Industry

The actual data for fuel consumed in each thermal plant was not readily available via sources but the total generation per year was available through Nepal Electricity Authority and the fuel consumption per hour was extracted via literature research and verified with NEA officials. With the available dataset, the total fuel consumption for energy generation has been calculated using equation

$$TFC = \sum Gen_{Plant} \times FE_{Plant}$$

Where,

TFC is the total fuel consumed in [kiloliters]
Gen is the generation by the plant in a year [MWh]
FE is the fuel economy of the plant [kiloliters per MWh] ≅ 250 liter per MWh

Manufacturing Industries

Total energy consumption in manufacturing industries is based on gross value added for each subsector, the energy intensities in each subsector and the fuel share by types in each subsector. Using this approach brings the uniformity in estimating energy consumption and therefore the emissions over the multiple periods of time (1994 to 2011 and 2012 to 2022). This approach is different than previous approximation methods – for instance, in INC report, it is based in total energy consumption, in SNC and TNC [1], it is based on product output. The total energy consumption is therefore derived using following formula

$$TE_i = \sum_f VA_i \times EI_i \times Share_{f,i} \times cf_f$$

Where,

$TE_{,i}$ is total consumption of energy in industry I [TJ]
VA i is value addition of industry i [TJ per Rupees]
Share f,i is share of energy f consumed by industry i [percent]
cf is the correction factor used for each year to balance the calculated energy consumed and the reported total energy consumed in transportation sector. It is done since parameters such as energy intensity and value addition at sub sectoral level are not available for every year, thus had to be estimated based on available data. To calibrate the variation in the fuel consumed, the calculated energy consumed has been adjusted by the factor with reference to the actual energy consumed in each year reported as per synopsis reports (WECS, 2023, 2022b, 2010, 1996).

The value addition of manufacturing industry are based on economic survey reports by Ministry of Finance and National accounts data by NSO (MoF, 2024, 2015; NSO, 2023), the sub sectoral breakdown

[1] In third national communication report, the emission from manufacturing industries are based on limited industrial sub sectors - but representing total industrial energy use.

of industrial value addition are based on reports by NSO (formerly) CBS (CBS, 2022b, 2014b, 2014c, 2008, 2002, 1998) and the energy share of specific industries are based on assimilation of information from provincial reports by WECS (WECS, 2024, 2022a, 2021c). The so estimated energy consumption is compared and calibrated to the final energy consumption in industrial sector as reported by Energy Sector Synopsis reports by WECS (WECS, 2023, 2022b, 2010, 1996, 1994).

Transportation Sector

$$TEC_{v,f} = \sum N_{v,f} \times OF_v \times Vkm_v \times FE_v \times cf_f$$

Where,

TEC v,f is the total energy consumed by vehicle type v using fuel f
N v,f, is the total number of vehicle registered of type v using fuel f
OF v is the operating factor of vehicle v representing the number f vehicle currently in operation
VKM v is the average annual distance travelled by vehicle v
FEv is the fuel economy of the vehicle
cf is the correction factor used for each year to balance the calculated energy consumed and the reported total energy consumed in transportation sector. It is done since parameters such as vehicle kilometers are not available for every year, thus had to be estimated based on available data for year 2013 (CBS, 2014a) and 2019 (WECS, 2024, 2022a, 2021a, 2021b). To calibrate the variation in the fuel consumed, the calculated energy consumed has been adjusted by the factor with reference to the actual energy consumed in each year reported as per synopsis reports (WECS, 2023, 2022b, 2010, 1996).

Annex V.IX Emission Factors in Energy Sector

Category	Fuel	CO_2	CH_4	N_2O	Remarks
		kg/TJ	**kg/TJ**	**kg/TJ**	
1 - Energy					
1.A - Fuel Combustion Activities					
1.A.1 - Energy Industries					
1.A.1.a - Main Activity Electricity and Heat Production					
1.A.1.a.i - Electricity Generation	Residual Fuel Oil	77,400.00	3.00	0.60	IPCC Tier 1
	Gas/Diesel Oil	74,100.00	3.00	0.60	IPCC Tier 1
1.A.2 - Manufacturing Industries and Construction					
	Wood / Wood Waste	112,000.00	30.00	4.00	IPCC Tier 1
	Other Primary Solid Biomass	100,000.00	30.00	4.00	IPCC Tier 1
	Other Bituminous Coal	94,600.00	10.00	1.50	IPCC Tier 1
	Other Kerosene	71,900.00	3.00	0.60	IPCC Tier 1
	Liquefied Petroleum Gases	63,100.00	1.00	0.10	IPCC Tier 1
	Gas/Diesel Oil	74,100.00	3.00	0.60	IPCC Tier 1
	Motor Gasoline	69,300.00	3.00	0.60	IPCC Tier 1
	Residual Fuel Oil	77,400.00	3.00	0.60	IPCC Tier 1
1.A.3 - Transport					
1.A.3.a - Civil Aviation					
1.A.3.a.i - International Aviation (International Bunkers) (1)	Jet kerosene	71,500.00	0.50	2.00	IPCC Tier 1
1.A.3.a.ii - Domestic Aviation	Jet kerosene	71,500.00	0.50	2.00	IPCC Tier 1
1.A.3.b - Road Transportation					
1.A.3.b.i - Cars	Motor Gasoline	69,300.00	33.00	3.20	IPCC Tier 1
	Gas/Diesel Oil	74,100.00	3.90	3.90	IPCC Tier 1
	Liquefied Petroleum Gases	63,100.00	62.00	0.20	IPCC Tier 1
1.A.3.b.ii - Light-duty trucks	Gas/Diesel Oil	74,100.00	3.90	3.90	IPCC Tier 1
1.A.3.b.iii - Heavy-duty trucks and buses	Gas/Diesel Oil	74,100.00	3.90	3.90	IPCC Tier 1
1.A.3.b.iv - Motorcycles	Motor Gasoline	69,300.00	33.00	3.20	IPCC Tier 1

1.A.3.e - Other Transportation					
1.A.3.e.ii - Off-road	Gas/Diesel Oil	74,100.00	4.15	28.60	IPCC Tier 1
1.A.4 - Other Sectors					
1.A.4.a - Commercial/Institutional	Other Bituminous Coal	94,600.00	10.00	1.50	IPCC Tier 1
	Gas/Diesel Oil	74,100.00	10.00	0.60	IPCC Tier 1
	Wood / Wood Waste	112,000.00	300.00	4.00	IPCC Tier 1
	Other Kerosene	71,900.00	10.00	0.60	IPCC Tier 1
	Liquefied Petroleum Gases	63,100.00	5.00	0.10	IPCC Tier 1
	Other Primary Solid Biomass	100,000.00	300.00	4.00	IPCC Tier 1
	Motor Gasoline	69,300.00	10.00	0.60	IPCC Tier 1
1.A.4.b - Residential	Other Biogas	54,600.00	5.00	0.10	IPCC Tier 1
	Charcoal	112,000.00	200.00	1.00	IPCC Tier 1
	Wood / Wood Waste	112,000.00	1,124.00	4.00	IPCC Tier 1 & IPCC Tier 3: Technology Specific for wood stoves
	Other Kerosene	71,900.00	10.00	0.60	IPCC Tier 1
	Liquefied Petroleum Gases	63,100.00	5.00	0.10	IPCC Tier 1
	Other Primary Solid Biomass	100,000.00	2,210.00	9.70	Agriculture residue IPCC Tier 1 & IPCC Tier 3
	Other Primary Solid Biomass	100,000.00	281.00	27.00	Animal Waste IPCC Tier 1 & IPCC Tier 3
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	Gas/Diesel Oil	74,100.00	10.00	0.60	IPCC Tier 1
	Motor Gasoline	69,300.00	10.00	0.60	IPCC Tier 1

- **Non-GHG emission factors**

	CO		NOx		NMVOC	
	g/GJ	g/kg fuel	g/GJ	g/kg fuel	g/GJ	g/kg fuel
Agriculture / forestry / fishing: Off-road vehicles and other machinery						
Diesel		9.57		2.77		31.46
Agriculture / forestry / fishing: Stationary						
Biomass	570.00		300.00		91.00	
Gaseous Fuels	29.00		23.00		74.00	
Liquid Fuels	93.00		20.00		306.00	
Commercial / institutional: stationary						
Biomass	570.00		300.00		91.00	
Gaseous Fuels	29.00		23.00		74.00	
Liquid Fuels	93.00		20.00		306.00	
Public electricity and heat production						
Biogas	156.00		10.00		198.00	
Biomass	90.00		7.31		81.00	
Gas oil	16.20		0.80		65.00	
Heavy Fuel Oil	15.10		2.30		142.00	
Residential plants						
Biomass	4,000.00		600.00		50.00	
Gaseous Fuels	26.00		1.90		51.00	
'Other' Liquid Fuels	57.00		0.69		51.00	
Road transport, heavy duty vehicles						

	CO		NOx		NMVOC	
	g/GJ	g/kg fuel	g/GJ	g/kg fuel	g/GJ	g/kg fuel
Diesel		6.10		0.90		25.95
Road transport, light duty vehicles						
Diesel		6.81		1.23		13.48
Petrol		118.70		7.42		5.93
Road transport, mopeds & motorcycles						
Petrol		244.88		92.74		7.23
Road transport, passenger cars						
Diesel		2.41		0.51		11.77
LPG		58.22		9.43		5.48
Petrol		48.36		7.75		3.98
Stationary combustion in manufacturing industries and construction						
Biomass	570.00		300.00		91.00	
Gaseous Fuels	29.00		23.00		74.00	
'Other' Liquid Fuels	66.00		25.00		513.00	
Solid Fuels	931.00		88.80		173.00	

Annex V.XGHG Emission trends

- **GHG emissions by type**

GHG emissions (Gg Co2 - EQ)				
	CO_2	CH_4	N_2O	**Total**
1994	1,470	8,522	493	10,485
1995	1,570	8,755	506	10,830
1996	1,852	8,069	420	10,341
1997	1,953	8,237	433	10,624
1998	2,227	8,412	445	11,084
1999	2,381	8,590	455	11,426
2000	3,203	8,774	474	12,451
2001	2,964	8,958	484	12,406
2002	2,920	9,303	495	12,718
2003	2,812	9,499	506	12,817
2004	2,904	9,703	517	13,124
2005	2,695	9,909	528	13,133
2006	3,064	10,121	541	13,726
2007	2,630	10,319	548	13,497
2008	2,632	10,522	558	13,711
2009	2,926	10,746	585	14,257
2010	3,870	10,573	595	15,037
2011	4,149	10,603	605	15,357
2012	4,437	8,844	517	13,797
2013	4,937	9,744	572	15,254
2014	4,979	10,906	600	16,485
2015	5,922	10,913	618	17,453
2016	5,823	10,924	615	17,362

GHG emissions (Gg Co2 - EQ)				
	CO_2	CH_4	N_2O	Total
2017	8,548	10,911	668	20,127
2018	10,007	10,974	701	21,682
2019	11,013	11,001	712	22,726
2020	9,348	11,119	666	21,132
2021	12,979	11,417	724	25,120
2022	13,568	10,736	711	25,014

GHG emissions by sectors

	GHG emissions (Gg CO_2 - eq)						
Years	**Electricity Generation**	**Manufacturing Industries**	**Transport**	**Commercial**	**Residential**	**Agriculture**	**Total**
1994	40.98	323.34	532.51	163.16	9,284.21	140.88	**10,485.08**
1995	53.31	343.21	572.96	170.52	9,536.73	153.54	**10,830.27**
1996	24.37	570.95	630.41	131.02	8,940.20	43.82	**10,340.78**
1997	26.02	306.59	881.36	143.93	9,199.16	66.68	**10,623.74**
1998	69.89	308.86	1,003.66	140.24	9,484.09	77.63	**11,084.38**
1999	74.12	344.58	1,107.60	156.93	9,693.95	49.11	**11,426.29**
2000	43.11	1,082.28	943.12	190.07	9,965.63	226.36	**12,450.57**
2001	16.44	804.45	1,002.37	210.60	10,134.54	237.63	**12,406.04**
2002	11.19	718.60	870.52	260.10	10,648.97	208.63	**12,718.01**
2003	2.94	642.54	906.84	272.69	10,773.00	218.64	**12,816.65**
2004	6.58	777.23	920.17	278.39	10,923.21	218.48	**13,124.06**
2005	8.93	658.10	960.54	273.01	11,003.75	228.90	**13,133.23**
2006	10.81	1,025.71	937.64	300.86	11,224.58	226.36	**13,725.96**
2007	8.94	636.52	968.78	251.42	11,407.99	223.54	**13,497.20**
2008	6.13	747.54	990.81	257.24	11,524.56	185.15	**13,711.43**
2009	6.14	697.26	1,416.78	262.00	11,601.71	273.42	**14,257.31**
2010	8.83	1,263.20	1,707.89	317.46	11,412.41	327.46	**15,037.25**
2011	2.49	1,432.14	1,797.44	340.91	11,451.96	332.18	**15,357.13**
2012	1.05	1,690.96	1,760.18	382.23	9,635.32	327.75	**13,797.50**
2013	12.80	2,037.22	1,866.99	462.58	10,537.14	337.08	**15,253.81**
2014	6.64	1,812.84	2,082.93	512.26	11,700.82	369.51	**16,485.01**
2015	0.88	2,402.26	2,308.72	623.46	11,717.03	400.76	**17,453.11**

	GHG emissions (Gg CO_2 - eq)						
Years	**Electricity Generation**	**Manufacturing Industries**	**Transport**	**Commercial**	**Residential**	**Agriculture**	**Total**
2016	0.10	2,799.80	1,983.58	617.78	11,619.45	341.04	**17,361.76**
2017	0.24	3,745.69	3,265.18	818.53	11,741.12	556.56	**20,127.32**
2018	0.09	4,186.12	3,994.41	956.86	11,867.75	676.36	**21,681.60**
2019	0.08	4,840.46	4,195.61	1,103.70	11,913.76	672.33	**22,725.94**
2020	0.04	4,634.66	2,618.11	1,111.42	12,072.08	695.99	**21,132.30**
2021	0.04	6,698.33	4,130.45	1,217.50	12,359.47	714.35	**25,120.13**
2022	0.02	7,140.07	4,761.97	540.95	12,166.47	404.81	**25,014.29**

Annex V.XI Comparison of CO2 emissions with IEA data

Year	Reference Approach	Sectoral Approach	IEA	Difference w.r.t.	
				Reference	Sectoral
1994	1,752	1,470	1,616	8%	-10%
1995	1,908	1,570	1,763	8%	-12%
1996	2,185	1,852	1,834	16%	1%
1997	2,245	1,953	2,100	6%	-8%
1998	2,348	2,227	2,203	6%	1%
1999	2,416	2,381	3,007	-24%	-26%
2000	3,206	3,203	3,100	3%	3%
2001	2,880	2,964	3,350	-16%	-13%
2002	2,803	2,920	2,671	5%	9%
2003	2,681	2,812	2,905	-8%	-3%
2004	2,569	2,904	2,697	-5%	7%
2005	2,569	2,695	3,074	-20%	-14%
2006	2,860	3,064	2,501	13%	18%
2007	2,508	2,630	2,578	-3%	2%
2008	2,561	2,632	2,882	-13%	-10%
2009	2,771	2,926	3,425	-24%	-17%
2010	3,788	3,870	4,122	-9%	-7%
2011	4,032	4,149	4,405	-9%	-6%
2012	3,757	4,437	4,963	-32%	-12%
2013	4,252	4,937	4,954	-17%	0%
***2014**	4,655	4,979		-	-
2015	5,860	5,922	6,010	-3%	-1%
2016	5,214	5,823	5,667	-9%	3%
2017	7,847	8,548	8,403	-7%	2%
2018	11,318	10,007	10,022	11%	0%
2019	9,753	11,013	11,352	-16%	-3%
2020	9,753	9,348	9,671	1%	-3%
2021	12,063	12,979	13,313	-10%	-3%
2022	12,376	13,568	13,123	-6%	3%

(IEA, 2024)

**2014 value of IEA has been adjusted to 2015 to make the trend comparable. This discrepancy should have arisen due to difference in reporting for the fiscal year. In Nepal, the fiscal year generally begins on July 16 and ends on July 15 of next year. Similar trend also applies to energy consumption data.*

Annex V.XII Uncertainty parameters

	Uncertainty					
	CO_2		CH_4		N_2O	
	Lower Limit	**Upper limit**	**Lower Limit**	**Upper limit**	**Lower Limit**	**Upper limit**
1 - Energy						
1.A - Fuel Combustion Activities						
1.A.1 - Energy Industries						
1.A.1.a.i - Electricity Generation						
Liquid Fuels	-2.5%	1.8%	-66.7%	233.3%	-66.7%	233.3%
1.A.2 - Manufacturing Industries and Construction						
Liquid Fuels	-2.6%	5.3%	-70.0%	233.3%	-70.0%	233.3%
Solid Fuels	-5.4%	5.4%	-70.0%	200.0%	-66.7%	233.3%
Biomass Solid	-15.3%	17.9%	-66.7%	233.3%	-62.5%	275.0%
1.A.3 - Transport						
1.A.3.a - Civil Aviation						
Liquid Fuels	-4.1%	2.5%	0.0%	0.0%	0.0%	0.0%
1.A.3.b - Road Transportation						
Liquid Fuels	-5.3%	2.6%	-233.3%	70.9%	-243.8%	95.5%
1.A.4.a - Commercial/Institutional						
Liquid Fuels	-2.6%	5.3%	-70.0%	200.0%	-70.0%	233.3%
Solid Fuels	-5.4%	5.4%	-70.0%	200.0%	-66.7%	233.3%
Biomass Solid	-15.3%	17.9%	-66.7%	200.0%	-62.5%	275.0%
1.A.4.b - Residential						
Liquid Fuels	-2.4%	4.0%	-70.0%	200.0%	-70.0%	233.3%
Biomass Solid	-15.3%	17.9%	-94.8%	200.0%	-70.0%	275.0%
Biomass Gas	-15.4%	20.9%	-70.0%	200.0%	-70.0%	200.0%
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms						
Liquid Fuels	-2.6%	5.3%	-66.7%	233.3%	-66.7%	233.3%

Annex VI. Industrial Processes and Product Use

Annex VI.I Activity Data

Annual cement production quantity from national clinkers in the years 1994-2022

Year	Cement Production (MT)
1994	315,514.00
1995	326,839.00
1996	309,466.00
1997	226,681.00
1998	139,080.00
1999	190,588.00
2000	205,835.00
2001	215,098.00
2002	233,000.00
2003	310,589.00
2004	279,412.00
2005	610,044.00
2006	613,643.00
2007	644,325.00
2008	631,043.33
2009	617,761.67
2010	604,480.00
2011	709,003.00
2012	952,625.68
2013	1,196,248.36
2014	1,439,871.04
2015	1,683,493.73
2016	1,620,564.75
2017	1,958,787.20
2018	2,928,449.56
2019	6,054,620.64
2020	7,083,906.15
2021	8,288,170.20
2022	9,697,159.13

Source: MOF/NRB/TNC

Annual mild steel production quantity in the years1994-2022

Year	Mild Steel Production (MT)
1994	71,023.00
1995	95,118.00
1996	91,583.00
1997	107,346.00
1998	91,291.00
1999	106,646.00
2000	131,354.00
2001	135,951.00
2002	140,000.00
2003	154,621.00
2004	169,310.00
2005	166,451.00
2006	168,355.67
2007	170,260.33
2008	172,165.00
2009	174,069.67
2010	175,974.33
2011	177,879.00
2012	256,593.00
2013	292,363.00
2014	313,821.00
2015	290,902.00
2016	229,218.00
2017	479,696.00
2018	632,748.65
2019	671,526.78
2020	396,830.38
2021	609,093.35
2022	633,929.61

Annual consumption of lubricating oil from 2008-2022

Year	Lubricating oil (TJ)
2008	189
2009	172
2010	130
2011	209
2012	288
2013	335
2014	383
2015	372
2016	407
2017	606
2018	730
2019	841
2020	720
2021	972
2022	129

Sources: DOC

Annual consumption of paraffin wax from 2008-2022

Year	Paraffin wax (TJ)
2008	153
2009	100
2010	47
2011	107
2012	167
2013	216
2014	164
2015	171
2016	177
2017	44
2018	51
2019	183
2020	68
2021	65
2022	59

Sources: DOC

Import of mixture containing PFC or HFC (2014-2022)

Year	Import of mixture containing PFC or HFC
2014	7,038.00
2015	8,015.00
2016	2,542.00
2017	8,969.00
2018	11,412.00
2019	39,043.00
2020	20,333.50
2021	22,072.60
2022	12,753.00

Source: MOF

Annual pulp and paper production quantity from 1994-2022

Year	Pulp and Paper Production (MT)	Source
1994	8,177	NRB/MOF/TNC
1995	8,863	NRB/MOF/TNC
1996	11,564	NRB/MOF/TNC
1997	13,575	NRB/MOF/TNC
1998	15,848	NRB/MOF/TNC
1999	19,459	NRB/MOF/TNC
2000	40,065	NRB/MOF/TNC
2001	41,267	NRB/MOF/TNC
2002	41,000	NRB/MOF/TNC
2003	43,009	NRB/MOF/TNC
2004	42,835	NRB/MOF/TNC
2005	28,958	NRB/MOF/TNC
2006	29,904	NRB/MOF/TNC
2007	31,399	NRB/MOF/TNC
2008	32,905	NRB/MOF/TNC
2009	29,012	Linear Interpolation
2010	25,119	Linear Interpolation
2011	21,226	NRB
2012	24,871	NRB
2013	22,174	NRB
2014	21,774	NRB
2015	19,377	NRB
2016	14,666	NRB
2017	18,894	NRB
2018	14,684	NRB
2019	19,864	NRB
2020	11,280	NRB
2021	7,462	NRB
2022	10,529	NRB

Annual food production quantity from 1994-2022

Year	Biscuits (MT)	Sugar (MT)	Animal Feeds (MT)	Beer (MT)	Liquor
1994	6,278	34,044	18,000	14,900.00	2,100.00
1995	6,789	49,227	19,500	16,776.00	2,500.00
1996	6,057	67,051	21,999	18,315.00	2,608.00
1997	6,868	63,374	24,000	21,497.00	2,800.00
1998	9,113	67,206	22,452	13,933.00	3,100.00
1999	11,810	68,512	22,893	18,753.00	3,345.00
2000	9,129	77,156	22,755	21,725.00	3,847.00
2001	9,585	78,313	21,617	23,354.00	3,885.00
2002	9,440	82,200	22,266	22,800.00	3,700.00
2003	9,638	92,064	24,159	23,096.00	4,003.00
2004	9,590	96,174	22,496	24,977.00	4,437.00
2005	6,157	94,436	31,246	30,663.00	8,947.00
2006	6,767	98,461	39,995	54,616.00	9,039.00
2007	7,377	103,384	48,745	78,569.00	9,490.00
2008	7,987	108,682	57,495	102,522.00	10,089.00
2009	8,597	180,650	66,244	126,475.00	11,907.00
2010	9,206	190,650	74,994	150,428.00	12,000.00
2011	9,816	136,778	83,743	174,381.00	88,340.00
2012	14,549	156,773	92,493	23,388.35	9,875.07
2013	15,554	161,071	120,731	27,892.48	9,895.91
2014	15,204	148,394	115,041	53,744.00	5,785.69
2015	13,060	116,411	127,191	59,466.00	5,845.48
2016	10,753	104,419	124,352	66,682.00	4,757.95
2017	11,695	63,528	124,394	72,296.80	7,118.52
2018	12,863	91,493	150,181	3,443,709.55	28,401.31
2019	12,111	97,510	152,185	2,503,489.31	30,661.79
2020	14,146	66,570	127,090	794,632.62	55,044.24
2021	14,473	83,892	167,971	105,738.78	34,134.64
2022	12,761	99,097	158,680	126,250.56	33,829.45

Sources: NRB/MOF

Annex VI.II Uncertainty Parameters

SN	Particulars	Value	Calculated
2A1	**Cement Production**		
1	Assumption of 95% clinker factor in portland cement	2-7%	4.50
3	Assumption that country output is 100% portland cement	35%	36.40
4	Use of estimated country (or aggregated plant) production data (national statistics)	10%	
2D1	**Lubricant**		
1	ODU Factor	50%	50.09
2	Carbon Content	± 3%	
3	Activity Data	10-20%	20.00
2D2	**Paraffin**		
1	ODU Factor	100%	100.12
2	Carbon Content	± 5%	
3	Activity Data	10-20%	20.00
2F1 a	**Refrigeration and Stationary Air Conditioning**		
1	Activity Data	5%	
2	Emission Factor	0%	

Annex VII. Livestock

Annex VII.I Activity Data (Livestock Population from 2011-2022)

(2011/2012 -2021/22)

Category	Cattle	Other Cattle	Buffaloes	Non-Dairy Buffalo	Sheep	Goat	Pigs	Fowl	Duck	Milking Cow	Milking Buffaloes	Laying Hen	Laying Duck	Rabbit
2011/12	7,244,944	6,245,981	5,133,139	3,802,102	807,267	9,512,958	1,137,489	45,171,185	376,916	998,963	1,331,037	7,907,468	174,978	15,138
2012/13	7,274,022	6,248,431	5,241,873	3,872,077	809,536	9,786,354	1,160,035	47,959,239	375,975	1,025,591	1,369,796	8,233,616	174,714	19,623
2013/14	7,243,916	6,219,403	5,178,612	3,832,775	789,216	10,177,531	1,190,138	48,079,406	390,209	1,024,513	1,345,837	8,350,237	179,447	25,437
2014/15	7,241,743	6,215,796	5,167,737	3,822,573	789,292	10,251,569	1,203,230	50,195,285	390,287	1,025,947	1,345,164	8,412,728	179,480	25,872
2015/16	7,302,808	6,276,673	5,168,809	3,813,425	800,658	10,986,114	1,291,308	68,630,638	392,255	1,026,135	1,355,384	12,353,515	180,927	32,213
2016/17	7,347,487	6,317,958	5,177,998	3,668,486	801,975	11,165,099	1,328,036	70,007,151	394,775	1,029,529	1,509,512	12,388,889	183,940	34,487
2017/18	7,376,306	6,336,768	5,277,819	3,741,871	800,749	11,647,319	1,435,369	72,245,732	404,670	1,039,538	1,535,948	12,517,558	186,912	75,740
2018/19	7,385,035	6,306,260	5,308,664	3,748,080	798,889	12,283,752	1,488,338	75,709,330	416,400	1,078,775	1,560,584	12,526,979	190,747	74,645
2019/20	7,458,885	6,292,729	5,257,591	3,622,099	806,079	12,811,953	1,519,593	82,598,879	427,226	1,166,156	1,635,492	12,927,842	191,701	34,610
2020/21	7,466,841	6,257,800	5,159,931	3,529,289	793,725	13,442,614	1,588,838	73,418,077	432,226	1,209,041	1,630,642	11,374,011	220,532	44,531
2021/22	7,413,197	6,190,136	5,132,931	3,466,104	771,205	13,990,703	1,504,624	66,803,117	605,944	1,223,061	1,666,827	10,131,642	302,473	43,236

Source: MoALD, STATISTICAL INFORMATION ON NEPALESE AGRICULTURE, Year book 2023

Annex VII.II Livestock Population from 1997/98-2014/15

(1997/98 -2014/15)											
Category	**Cattle**	**Buffaloes**	**Sheep**	**Goat**	**Pigs**	**Fowl**	**Duck**	**Milking Cow**	**Milking Buffaloes**	**Laying Hen**	**Laying Duck**
1997/98	7,048,660	3,419,150	869,142	6,080,060	765,718	16,664,730	416,943	826,320	882,140	5,181,880	218,687
1998/99	7,030,698	3,470,600	855,159	6,204,616	825,132	17,796,826	421,423	828,214	896,415	5,420,900	220,400
1999/00	7,023,166	3,525,952	851,913	6,325,144	877,681	18,619,636	425,160	840,673	910,753	5,667,817	222,401
2000/01	6,982,660	3,624,020	850,170	6,478,380	912,530	19,790,060	411,410	852,583	936,811	5,998,367	215,376
2001/02	6,978,690	3,700,864	840,141	6,606,858	934,461	21,370,420	408,584	852,790	958,530	6,453,860	214,090
2002/03	6,953,584	3,840,013	828,286	6,791,861	932,192	22,260,700	408,311	870,589	988,035	6,622,558	213,751
2003/04	6,966,436	3,952,654	824,187	6,979,875	935,076	23,023,979	405,217	888,190	1,015,727	6,676,954	211,838
2004/05	6,994,463	4,081,463	816,727	7,153,527	947,711	2,2790,224	391,855	902,286	1,050,977	6,643,350	183,208
2005/06	7,002,916	4,204,886	812,085	7,421,624	960,827	23,221,439	392,895	903,376	1,084,764	6,769,050	183,690
2006/07	7,044,279	4,366,813	813,621	7,847,624	989,429	23,924,630	394,798	908,712	1,124,454	6,962,076	184,608
2007/08	7,090,714	4,496,507	809,480	8,135,880	1,013,359	24,665,820	390,748	915,411	1,158,300	7,153,088	182,753
2008/09	7,175,198	4,680,486	802,993	8,473,082	1,044,498	24,481,286	383,123	932,876	1,211,495	7,124,054	179,187
2009/10	7,199,260	4,836,984	801,371	8,844,172	1,064,858	25,760,373	379,753	954,680	1,252,770	7,290,875	175,300
2010/11	7,226,050	4,993,650	805,070	9,186,440	1,108,465	40,000,000	378,050	974,122	1,291,644	7,478,645	175,150
2011/12	7,244,944	5,133,139	807,267	9,512,958	1,137,489	45,171,185	376,916	998,963	1,331,037	7,907,468	174,978
2012/13	7,274,022	5,241,873	809,536	9,786,354	1,160,035	47,959,239	375,975	1,025,591	1,369,796	8,233,616	174,714
2013/14	7,243,916	5,178,612	789,216	10,177,531	1,190,138	48,079,406	390,209	1,024,513	1,345,837	8,350,237	179,447
2014/15	7,241,743	5,167,737	789,292	10,251,569	1,203,230	50,195,285	390,287	1,025,947	1,345,164	8,412,728	179,480

Source: MOAD 2013, 2015

Annex VII.III Emission factor for Livestock Sector for Indian Subcontinent

SN	Livestock	Emission Factor for CH_4 from enteric fermentation (kg CH_4 head^{-1} yr^{-1})	Emission Factor for CH_4 from manure management (kg CH_4 head^{-1} yr^{-1})
1	Dairy Cows	58	5
2	Non-dairy Cows	27	2
3	Buffalo	55	5
4	Sheep	5	0.15
5	Goat	5	0.17
6	Swine	1	4
7	Horse	18	1.64
8	Mules and Asses	10	0.9
9	Poultry		0.02
10	Rabbit		0.08

Annex VII.V Recalculation of Emission for Livestock Setor Summary Table

Year	Enteric Fermentation (CH_4 enteric)	Manure_mgmt (CH_4 manure)			Total Gg CO_2-eq
	Gg CO_2-eq	Gg CO_2-eq	Total Gg CO_2-eq (CH_4)	Gg CO_2-eq (N_2O)	
1994	11,408	981	12,389	242	12,631
1995	11,830	1,017	12,848	248	13,096
1996	12,024	1,036	13,060	253	13,313
1997	12,179	1,055	13,234	258	13,492
1998	12,317	1,072	13,388	264	13,652
1999	12,401	1,086	13,487	268	13,756
2000	12,510	1,101	13,611	273	13,884
2001	12,663	1,119	13,782	279	14,061
2002	12,796	1,133	13,929	284	14,213
2003	13,031	1,154	14,185	290	14,475
2004	13,255	1,174	14,429	297	14,726
2005	13,510	1,197	14,707	303	15,010
2006	13,745	1,217	14,962	313	15,275
2007	14,091	1,248	15,339	327	15,666
2008	14,372	1,274	15,646	337	15,983
2009	14,781	1,311	16,092	349	16,441
2010	15,111	1,341	16,452	362	16,814
2011	15,439	1,380	16,820	377	17,197

Annex VII.VI National Communication Emission from Livestock Sector

National Communication	Total Gg CO_2-eq (livestock Sector)
INC	12,401
SNC	12,308
TNC	17,664.07

Annex VII.VII Total Emission for Livestock sector for 2022

Total emission for livestock sector (Gg)	651.97	%
CH4 (EF)	0.914	91.407
CH4(manure)	0.083	8.290
N2O	0.003	0.303

Annex VII.VIII GHG Emission Trend from Livestock Sector

Year	CH_4_Enteric (Gg)	CH_4 enteric Gg CO_2-eq	CH_4 _manure mgmt (Gg)	CH_4 manure Gg CO_2-eq	N_2O_manure mgmt (Gg)	N_2O Gg CO_2-eq	Total Gg CO_2 -eq
1994	407.44	11,408.39	35.03	980.73	0.91	241.79	12,630.91
1995	422.51	11,830.31	36.33	1,017.23	0.94	248.14	13,095.68
1996	429.42	12,023.83	37.01	1,036.21	0.95	252.64	13,312.67
1997	434.96	12,178.91	37.70	1,055.49	0.97	258.05	13,492.45
1998	439.88	12,316.62	38.28	1,071.71	1.00	263.86	13,652.19
1999	442.91	12,401.41	38.78	1,085.93	1.01	268.47	13,755.81
2000	446.79	12,510.01	39.33	1,101.24	1.03	273.04	13,884.29
2001	452.26	12,663.28	39.96	1,119.01	1.05	278.80	14,061.09
2002	457.00	12,795.88	40.48	1133.46	1.07	283.66	14,213.00
2003	465.38	13,030.70	41.22	1,154.09	1.10	290.30	14,475.09
2004	473.39	13,254.88	41.92	1,173.68	1.12	297.00	14,725.55
2005	482.51	13,510.17	42.73	1,196.53	1.14	303.38	15,010.08
2006	490.88	13,744.71	43.48	1,217.33	1.18	312.50	15,274.54
2007	503.23	14,090.52	44.59	1,248.38	1.23	326.91	15,665.82
2008	513.27	14,371.50	45.51	1,274.14	1.27	336.99	15,982.64
2009	527.89	14,780.92	46.82	1,311.04	1.32	349.04	16,441.00
2010	539.69	15,111.22	47.89	1,340.88	1.36	361.72	16,813.82
2011	551.40	15,439.15	49.30	1,380.47	1.42	377.38	17,197.00
2012	562.02	15,736.53	50.39	1,410.84	1.47	389.57	17,536.94
2013	571.00	15,987.96	51.26	1,435.30	1.51	399.51	17,822.78
2014	568.55	15,919.26	51.07	1,429.94	1.55	409.94	17,759.15
2015	568.30	15,912.52	51.12	1,431.33	1.56	412.33	17,756.18
2016	573.82	16,067.05	52.09	1,458.63	1.65	438.48	17,964.16
2017	576.57	16,143.86	52.44	1,468.42	1.68	444.48	18,056.76
2018	585.65	16,398.06	53.59	1,500.48	1.74	462.22	18,360.76

2019	592.01	16576.20	54.27	1519.45	1.82	481.46	18577.12
2020	596.60	16704.72	54.77	1533.56	1.87	496.04	18734.32
2021	595.92	16685.64	54.62	1529.49	1.93	511.22	18726.35
2022	595.95	16686.64	54.05	1513.33	1.98	523.53	18723.50

Annex VII.IX Annual growth rate of livestock population

Livestock category	**Average Annual growth rate**
Cattle	0.2311
Dairy Cattle	2.0733
Other Cattle	-0.0881
Buffaloes	0.0069
Sheep	-0.4470
Goat	3.9476
Pigs	2.8970
Poultry	4.6476
Rabbit	18.2831
Horse	-4.7410
Mules	0.3868

Annex VIII. Agriculture

Annex VIII.I Activity data

Year	Urea Application (ton)	DAP Application (ton)	Lime Application (AICL)	Rice harvested area
1994	103,201	35,217	267.325	1,450,449
1995	117,716	52,806	267.325	1,368,423
1996	82,849	46,243	267.325	1,496,790
1997	77,577	41,921	267.325	1,511,230
1998	59,110	28,530	267.325	1,506,340
1999	59,956	26,298	267.325	1,514,210
2000	43,508	26,156	267.325	1,550,990
2001	29,528	15,633	267.325	1,560,044
2002	17,697	20,645	267.325	1,516,980
2003	34,449	33,331	267.325	1,544,660
2004	7,428	11,377	267.325	1,559,436
2005	10,043	19,436	267.325	1,541,729
2006	1,960	10,857	267.325	1,549,447
2007	14,985	7,437	267.325	1,439,525
2008	2,500	1,990	267.325	1,549,262
2009	5,935	0	267.325	1,555,940
2010	5048.9	2,523.11	267.325	1,481,289
2011	8,5190.97	22,001.4	267.325	1,496,476
2012	97,956.52	43,146.06	267.325	1,531,493
2013	108,553	65,722	267.325	1,420,570
2014	145,622	81,520	267.325	1,486,951
2015	190,163	101,797	267.325	1,425,346
2016	213,063	107,121	267.325	1,362,908
2017	205,425	114,802	267.325	1,552,469
2018	23,530	105,619	267.325	1,469,545
2019	215,733	120,893	267.325	1,491,744
2020	224,700	160,298	424.05	1,458,915
2021	225,180	140,482	482.325	1,473,474
2022	143,482	77,720	1004.975	1,477,378

Source: Statistical Information on Nepalese Agriculture, MoAC/MoALD, Agriculture Input Company Limited

Annex VIII.II Calculation sheet for CO_2 emission from urea application

Sector	**Agriculture, Forestry and Other Land Use**			
Category	**Urea Fertilization: Annual CO_2 emissions from Urea Fertilization**			
Category code	**3C3**			**Year: 2011**
Sheet	**1 of 1**			
Equation	**Equation 11.13**			
Subcategories for reporting year	Annual amount of Urea Fertilization	Emission factor	Annual CO_2-C emissions from Urea Fertilization	Annual CO_2 emissions from Urea Fertilization
	(tonnes urea yr^{-1})	[tonnes of C (tonne of urea)$^{-1}$]	(tonnes C yr^{-1})	(tonnes C yr^{-1})
		default is 0.20	CO_2-C Emission = M * EF	CO_2 Emission = CO2-C Emission *44/12
	M	**EF**	**CO_2-C Emission**	**CO_2 Emission**
(a)	851901	0.2	392	62473.37433
(b)				
(c)				
Total				

Annex VIII.III Calculated CO_2 emission per year (in tonnes) for urea application

Year	CO_2 emissions (tonnes per year)
1994	75,680.73
1995	86,325.07
1996	60,755.93
1997	56,889.80
1998	43,347.33
1999	43,967.73
2000	31,905.87
2001	21,653.87
2002	12,977.80
2003	25,262.60
2004	5,447.20
2005	7,364.87
2006	1,437.33
2007	10,989.00
2008	1,833.33

2009	4,352.33
2010	3,702.53
2011	62,473.37
2012	71,834.78
2013	79,605.53
2014	106,789.47
2015	139,452.87
2016	156,246.20
2017	150,645.00
2018	172,556.27
2019	158,204.20
2020	164,780.00
2021	165,132.00
2022	105,220.13

Annex VIII.IV Annual harvested area of rice

YEAR	AREA (ha)	YEAR	AREA (ha)
1993/94	1,450,449		
1994/95	1,368,423	2008/09	1,555,940
1995/96	1,496,790	2009/10	1,481,289
1996/97	1,511,230	2010/11	1,496,476
1997/98	1,506,340	2011/12	1,531,493
1998/99	1,514,210	2012/13	1,420,570
1999/00	1,550,990	2013/14	1,486,951
2000/01	1,560,044	2014/15	1,425,346
2001/02	1,516,980	2015/16	1,362,908
2002/03	1,544,660	2016/17	1,552,469
2003/04	1,559,436	2017/18	1,469,545
2004/05	1,541,729	2018/19	1,491,744
2005/06	1,549,447	2019/20	1,458,915
2006/07	1,439,525	2020/21	1,473,474
2007/08	1,549,262	2021 /22	1,477,378

Source: Statistical Information on Nepalese Agriculture, MoAC/MoALD

Annex VIII.V Calculated GHG emissions from different sources (in Gg CO2-equivalent) from year 1994 to 2022.

Year	Liming (CO2)	Urea Application (CO2)	Rice Cultivation (CH4)	Direct N2O (Managed Soils)	Indirect N2O (Managed Soils)	Indirect N2O (manure management)	Total CO2 eq emission
1994	0.141	75.681	2038.015	1037.778	411.920	25.123	3588.658
1995	0.141	86.325	1922.761	1088.637	435.539	25.802	3559.206
1996	0.141	60.756	2103.129	1066.554	417.553	26.631	3674.764
1997	0.141	56.890	2294.916	1076.305	419.567	28.098	3875.917
1998	0.141	43.347	2287.490	1067.745	410.789	29.442	3838.955
1999	0.141	43.968	2299.441	1076.752	414.506	30.893	3865.701
2000	0.141	31.906	2355.295	1071.822	408.614	32.064	3899.842
2001	0.141	21.654	2369.044	1070.078	403.748	33.372	3898.036
2002	0.141	12.978	2303.648	1072.328	402.240	34.934	3826.269
2003	0.141	25.263	2345.682	1113.829	423.255	35.746	3943.916
2004	0.141	5.447	2368.121	1100.789	409.740	36.508	3920.747
2005	0.141	7.365	2341.231	1127.174	420.953	36.430	3933.294
2006	0.141	1.437	2352.952	1138.159	422.772	36.916	3952.377
2007	0.141	10.989	2186.027	1182.666	443.329	37.801	3860.953
2008	0.141	1.833	2352.671	1194.173	444.426	38.682	4031.926
2009	0.141	4.352	2362.812	1231.935	459.514	38.840	4097.594
2010	0.141	3.703	2249.448	1263.820	472.025	40.215	4029.352
2011	0.141	62.473	2357.423	1385.977	541.265	53.389	4400.667
2012	0.141	71.835	2412.586	1435.606	565.989	58.331	4544.487
2013	0.141	79.606	2237.847	1479.813	587.250	61.091	4445.748
2014	0.141	106.789	2342.418	1524.241	616.188	61.389	4651.166
2015	0.141	139.453	2245.371	1576.455	649.253	63.374	4674.046
2016	0.141	156.246	2147.011	1635.525	681.047	80.598	4700.569
2017	0.141	150.645	2445.629	1640.160	681.989	82.134	5000.698
2018	0.141	172.556	2314.998	1695.877	711.061	84.976	4979.609

2019	0.141	158.204	2349.968	1711.111	714.824	88.606	5022.855
2020	0.224	164.780	2298.252	1760.286	740.181	95.359	5059.082
2021	0.255	165.132	2321.187	1764.332	741.538	87.755	5080.199
2022	0.531	105.220	2327.337	1673.181	682.552	81.425	4870.245

Annex IX. LULUCF

Annex IX.I Sample of land representation matrix

		2011-2012		2012-2013		2020-2021		2021-2022	
IPCC Land Use	**Land Use Category**	**Area (ha)**	**Percent (%)**	**Area (ha)**	**Percent (%)**	**Area (ha)**	**Percent (%)**	**Area (ha)**	**Percent (%)**
Forest Land	Forest Land Remaining Forest Land	7438071.51	44.08	7444582.47	44.11	7479722.52	44.32	7386377	43.77
	Cropland Converted to Forest Land	45764.52	0.27	47209.86	0.28	179584.74	1.06	258812.8	1.53
	Grassland Converted to Forest Land	29229.39	0.17	30501.18	0.18	156111.12	0.93	111782.3	0.66
	Wetlands Converted to Forest Land	333.15	0.00	306.27	0.00	286.29	0.00	423.9	0.00
	Settlements Converted to Forest Land	1.95	0.00	1.8	0.00	134.55	0.00	257.67	0.00
	Other Lands Converted to Forest Land	595.86	0.00	329.31	0.00	5079.87	0.03	3851.28	0.02
Cropland	Cropland Remaining Cropland	4234845.99	25.09	4226597.28	25.05	3726406.8	22.08	3277906	19.42
	Forest Land Converted to Cropland	31148.43	0.18	30833.19	0.18	142480.53	0.84	222490.4	1.32
	Grassland Converted to Cropland	10733.79	0.06	9998.64	0.06	23375.7	0.14	250287.9	1.48
	Wetlands Converted to Cropland	6268.68	0.04	5763.78	0.03	5706.99	0.03	9204.3	0.05
	Settlements Converted to Cropland	41.67	0.00	38.52	0.00	679.32	0.00	5585.85	0.03

	Other Lands Converted to Cropland	5.97	0.00	6.39	0.00	757.08	0.00	30231.72	0.18
Grassland	Grassland Remaining Grassland	2128098.9	12.61	2148311.07	12.73	1634208.03	9.68	1518440	9.00
	Forest Land Converted to Grassland	25382.58	0.15	24999.39	0.15	168011.64	1.00	159665.9	0.95
	Cropland Converted to Grassland	9828.57	0.06	9306.9	0.06	49924.53	0.30	14405.85	0.09
	Wetlands Converted to Grassland	2747.43	0.02	2475.81	0.01	15471.27	0.09	8655.57	0.05
	Settlements Converted to Grassland	87.03	0.00	98.55	0.00	465.84	0.00	1527.3	0.01
	Other Lands Converted to Grassland	183731.1	1.09	149637.87	0.89	389729.97	2.31	792218.5	4.69
Wetlands	Wetlands Remaining Wetlands	230456.7	1.37	227082.24	1.35	98706.42	0.58	99715.5	0.59
	Forest Land Converted to Wetlands	494.52	0.00	458.28	0.00	483.3	0.00	531.18	0.00
	Cropland Converted to Wetlands	3528.12	0.02	3811.14	0.02	6548.94	0.04	17743.5	0.11
	Grassland Converted to Wetlands	2356.11	0.01	2381.67	0.01	13096.8	0.08	62531.19	0.37
	Settlements Converted to Wetlands	45.45	0.00	49.32	0.00	437.76	0.00	3390.66	0.02
	Other Lands Converted to Wetlands	406.62	0.00	303.57	0.00	289.89	0.00	14877.27	0.09
Settlements	Settlements Remaining Settlements	37631.31	0.22	37895.4	0.22	115161.57	0.68	152009.2	0.90

Annex IX.II : Emission Factor and Default Value for Land Use and Forestry Sector

Activity		**IPCC Emission Factor**	**Default Value**
Land Use Category			
Forest land			
Forest land remains Forest	**Annual increase in carbon stocks in biomass (includes above-ground and below-ground biomass)**	Average annual above-ground biomass growth	Default values varies with climatic regime Tables 4.9, 4.10 and 4.12
		Ratio of below-ground biomass to above-ground biomass	0.24
		Carbon fraction of dry matter	0.47
	Loss of carbon from wood removals	Biomass conversion and expansion factor for conversion of removals in merchantable volume to total biomass removals (including bark)	0.67
		Ratio of below-ground biomass to above-ground biomass	0.24
		Basic wood density	0.45
		Carbon fraction of dry matter	0.47
		Emission factor for climate type	Default values Varies with climatic regime Table 4.6
	Loss of carbon from fuelwood removals	Biomass conversion and expansion factor for conversion of removals in merchantable volume to biomass removals (including bark)	0.67
		Ratio of below-ground biomass to above-ground biomass	0.24
		Basic wood density	0.45
		Carbon fraction of dry matter	0.47
	Annual carbon loss from drained organic soils	Emission factor for climate type	Default values Varies with climatic regime Table 4.6
Land Converted to Forest	**Annual increase in carbon stocks in biomass (includes above- and below-ground biomass)**	Average annual above-ground biomass growth	2.76
		Ratio of below-ground biomass to above-ground biomass	0.368
		Carbon fraction of dry matter	0.47

	Loss of carbon from wood removals1	Biomass conversion and expansion factor for conversion of removals in merchantable volume to total biomass removals (including bark)	0.67
		Ratio of below-ground biomass to above-ground biomass	0.368
		Carbon fraction of dry matter	0.47
	Annual change in carbon stocks in dead organic matter due to land conversion	Dead wood/litter stock, under the new land-use category	20.92
		Dead wood/litter stock, under the old land-use category	0
		Time period of the transition from old to new land-use category	10
	Annual change in carbon stocks in mineral soils	Reference carbon stock for the climate and soil combination	45.4
		Time dependence of stock change factors (D) or number of years over a single inventory time period (T)	10
		Stock change factor for land-use system in the last year of an inventory time period	1
		Stock change factor for management regime in last year of an inventory period	1
		Stock change factor for C input in the last year of the inventory period	1
		Stock change factor for land-use system at the beginning of the inventory time period	1
		Stock change factor for management regime at the beginning of the inventory time period	1
		Stock change factor for C input at the beginning of the inventory time period	1
	Annual change in carbon stocks in organic soils	Emission factor for climate type	0.73
Crop land			

Crop land Remaining Crop land	**Annual change in carbon stocks in biomass**	Annual growth of perennial woody biomass2	Default values Varies climatic regime Table 5.1
		Annual carbon stock in biomass removed (removal or harvest)	Default values Varies climatic regime Table 5.1
	Annual change in carbon stocks in mineral soils	Reference carbon stock in the last year of an inventory period	45.4
		Reference carbon stock at the beginning of an inventory period	45.4
		Time dependence of stock change factors (D) or number of years over a single inventory time period (T)	10
		Stock change factor for land-use system or sub-system	1
		Stock change factor for management regime	1
		Stock change factor for input of organic matter	1
	Annual change in carbon stocks in organic soils	Emission factor for climate type	5
Land Converted to Cropland	**Annual change in carbon stocks in biomass**	Biomass stocks before the conversion	T Default values Varies climatic regime Table 5.8
		Carbon fraction of dry matter	0.5
		Annual biomass carbon growth	4.12
		Annual loss of biomass carbon3	35.75
	Annual change in carbon stocks in dead organic matter due to land conversion1	Dead wood/litter stock under the old land-use category	3.5
		Dead wood/litter stock under the new land-use category	0
		Time period of the transition from old to new land-use category	1
	Annual change in carbon stocks in mineral soils	Reference carbon stock for the climate/soil combination	45.4
		Time dependence of stock change factors (D) or number of years over a single inventory time period (T)	10

		Stock change factor for land-use system in the last year of an inventory time period	1
		Stock change factor for management regime in last year of an inventory period	1
		Stock change factor for C input in the last year of the inventory period	1
		Stock change factor for land-use system at the beginning of the inventory time period	1
		Stock change factor for management regime at the beginning of the inventory time period	1
		Stock change factor for C input at the beginning of the inventory time period	1
	Annual change in carbon stocks in organic soils	Emission factor for climate type	11.66
Grassland			
Grassland Remaining Grassland	**Annual change in carbon stocks in mineral soils**	Reference carbon stock for Climate/Soil Combination	45.4
		Stock change factor for land-use system or sub-system	1
		Stock change factor for management regime	1
		Stock change factor for C input	1
	Annual change in carbon stocks in organic soils	Emission factor for climate type	2.5
Land Converted to Grassland	**Annual change in carbon stocks in biomass**	Biomass stocks after the conversion	6.2
		Biomass stocks before the conversion	10.22
		Carbon fraction of dry matter	0.48
	Annual change in carbon stocks in dead organic matter due to land conversion	Dead wood/litter stock under the old land-use category	3.55
		Dead wood/litter stock under the new land-use category	0

		Time period of the transition from old to new land-use category	1
	Annual change in carbon stocks in mineral soils	Reference carbon stock for the climate and soil combination	45.4
		Time dependence of stock change factors (D) or number of years over a single inventory time period (T)	10
		Stock change factor for land-use system in the last year of an inventory time period	1
		Stock change factor for management regime in last year of an inventory period	1
		Stock change factor for C input in the last year of the inventory period	1
		Stock change factor for land-use system at the beginning of inventory time period	1
		Stock change factor for management regime at the beginning of the inventory time period	1
		Stock change factor for C input at the beginning of the inventory time period	1
	Annual change in carbon stocks in organic soils	Emission factor for climate type	3
Settlement			
Settlement Remaining Settlement	**Annual change in carbon stocks in organic soils**	Emission factor for climate type	10
Land Converted to Settlement	**Annual change in carbon stocks in biomass**	Biomass stocks before the conversion	Default values Varies land use category see Table 5.8
		Carbon fraction of dry matter	0.5
		Annual biomass carbon growth	4.12
		Annual loss of biomass carbon	35.75
		Dead wood/litter stock, under the new land-use category	3.55

	Annual change in carbon stocks in dead organic matter due to land conversion1	Dead wood/litter stock, under the old land-use category	0
		Time period of the transition from old to new land-use category	1
	Annual change in carbon stocks in mineral soils	Reference carbon stock for the climate/soil combination	45.4
		Time dependence of stock change factors (D) or number of years over a single inventory time period (T)	10
		Stock change factor for land-use system in the last year of an inventory time period	1
		Stock change factor for management regime in last year of an inventory period	1
		Stock change factor for C input in the last year of the inventory period	1
		Stock change factor for land-use system at the beginning of the inventory time period	1
		Stock change factor for management regime at the beginning of the inventory time period	1
		Stock change factor for C input at the beginning of the inventory time period	1
	Annual change in carbon stocks in organic soils	Emission factor for climate type	11.66
Land Converted to other land	**Annual change in carbon stocks in biomass**	Biomass stocks before the conversion	Default values Varies land use category see Table 5.8
		Carbon fraction of dry matter	0.5
		Annual biomass carbon growth	4.12
		Annual loss of biomass carbon	35.75

		Reference carbon stock for the climate/soil combination	45.4
		Time dependence of stock change factors (D) or number of years over a single inventory time period (T)	10
		Stock change factor for land-use system in the last year of an inventory time period	1
	Annual change in carbon stocks in mineral soils	Stock change factor for management regime in last year of an inventory period	1
		Stock change factor for C input in the last year of the inventory period	1
		Stock change factor for land-use system at the beginning of the inventory time period	1
		Stock change factor for management regime at the beginning of the inventory time period	1
		Stock change factor for C input at the beginning of the inventory time period	1
	Annual change in carbon stocks in organic soils	Emission factor for climate type	11.66
Biomass Burning From Forest Land	**Emission factor for each GHG**	CH_4	6.8
		CO	104
		N_2O	0.26
		NO_x	1.6
Urea Application	**Annual CO2 emissions from Urea Fertilization**	Emission factor	0.2
Indirect N2O Emissions from Managed Soils	**N2O from Atmospheric Deposition of N Volatilized from Managed Soils**	Fraction of synthetic fertilizer N that volatilizes	0.1
		Fraction of applied organic N fertilizer materials (FON) and of urine and dung N deposited by grazing animals (FPRP) that volatilizes	0.2

		Emission factor for N2O emission from atmospheric deposition of N on soils and water surfaces	0.01
	N2O from N leaching/runoff from Managed Soils	Fraction of all N additions to managed soils that is lost through leaching and runoff	0.3
		Emission factor for N2O emission from N leaching and runoff	0.0075
Indirect N2O Emissions from Manure Management1		Fraction of managed livestock manure nitrogen that volatilizes	Default values vary with animal type see Table 10.22
		Emission factor for N2O emissions from atmospheric deposition of nitrogen on soils and water surfaces	0.01
		Amt. of managed manure nitrogen for livestock category T that is lost in the Manure Management Sys.	Default values varies with animal type see Table 10.23
		Fraction of total annual nitrogen excretion managed in MMS for each species/livestock category	23
		Amount of nitrogen from bedding	0
Rice Cultivation	**Annual CH4 emission from rice**	Baseline emission factor for continuously flooded fields without organic amendments	1.3
		Scaling factor to account for the differences in water regime during the cultivation period	0.78
		Scaling factor to account for the differences in water regime in the pre-season before the cultivation period	1.22
		Conversion factor for organic amendment	0.1

Annex IX.III CO_2 emission/removal from LULUCF

Year	Forest Land	Cropland	Grassland	Settlement
1994	-10791.4938	0	0	0
1995	-10791.4938	0	0	0
1996	-10791.4938	0	0	0
1997	-10791.4938	0	0	0
1998	-10791.4938	0	0	0
1999	-10791.4938	0	0	0
2000	-10791.4938	0	0	0
2001	-10791.4938	0	0	0
2002	-10421.8821	174.7298	371.7668	-5.28964
2003	-11201.0355	550.1987	1865.493	-22.4973
2004	-11727.1602	827.8116	1762.757	-39.3187
2005	-12194.2854	1073.38	4157.309	-48.3197
2006	-12409.424	1202.161	3301.024	-61.5837
2007	-12512.9261	1260.02	4100.982	-71.5241
2008	-12657.0005	1271.963	3233.828	-89.6755
2009	-12801.0747	1283.906	2366.674	-107.827
2010	-12900.5158	1314.522	1077.819	-125.599
2011	-13063.0981	1300.261	2113.252	-138.405
2012	-13220.3291	1346.675	2346.285	-143.543
2013	-13377.5601	1436.761	2579.318	-148.681
2014	-13534.7911	1504.881	2812.351	-153.819
2015	-13971.0362	1706.605	3698.237	-189.564
2016	-14466.8985	2022.305	871.4913	-261.844
2017	-14926.9298	2463.022	1099.433	-380.029
2018	-15554.4214	3025.483	1196.18	-942.598
2019	-15544.4781	3384.889	4127.995	-958.587
2020	-18348.8385	4317.132	4771.509	-1414.02
2021	-18778.8371	5449.572	4005.21	-2153.2
2022	-18072.1001	6345.516	-38.7942	-8256.58

Annex IX.IV Area (in Hectares) in LULUCF from 2001 to 2022

Year	Forest Land	Cropland Annual	Cropland Perennial	Grassland	Wetlands	Settlements	Other Lands	Total Land
2001	7367045.49	4413141.2	25261	2516412.15	272140.29	29753.73	2251711.26	16875465.12
2002	7346042.64	4394964.35	26350	2492408.61	270775.35	30081.6	2314842.57	16875465.12
2003	7390317.33	4358432.01	27033	2395964.52	270052.29	31148.19	2402517.78	16875465.12
2004	7420213.89	4327908.49	29841.2	2402597.79	268307.82	32190.84	2394405.09	16875465.12
2005	7446757.86	4302756.9	31113	2247990.84	267659.55	32748.75	2546438.22	16875465.12
2006	7458982.92	4289763.62	31651	2303277.84	267363.72	33570.9	2490855.12	16875465.12
2007	7464864.33	4283220.19	32355.5	2251627.65	264497.13	34187.04	2544713.28	16875465.12
2008	7473051.23	4280435.56	33441.25	2307616.43	259243.38	35312.13	2486365.14	16875465.12
2009	7481238.12	4277650.92	34527	2363605.2	253989.63	36437.22	2428017.03	16875465.12
2010	7486888.77	4273358.56	35444	2446821.54	249049.89	37538.82	2346363.54	16875465.12
2011	7496127.36	4252941.99	49716	2379967.65	243690.12	38332.53	2414689.47	16875465.12
2012	7505061.87	4232812.26	60039	2364921.63	240488.82	38651.01	2433490.53	16875465.12
2013	7513996.38	4220545.53	62499	2349875.61	237287.52	38969.49	2452291.59	16875465.12
2014	7522930.89	4204323.8	68914	2334829.59	234086.22	39287.97	2471092.65	16875465.12
2015	7547720.13	4179253.73	72850	2277631.35	234371.88	41503.59	2522134.44	16875465.12
2016	7575897.06	4146879.51	74511	2460143.34	240984.36	45983.7	2331066.15	16875465.12
2017	7602037.92	4097808.26	79372	2445426	250639.29	53309.25	2346872.4	16875465.12
2018	7637694.57	4045096.8	79074	2439179.46	257481.45	88179.21	2328759.63	16875465.12
2019	7637129.55	4008063.69	81081	2249883.54	268920.81	89170.29	2541216.24	16875465.12
2020	7796484.81	3938843.61	68688	2208334.32	121791.06	117399.51	2623923.81	16875465.12
2021	7820919.09	3828656.42	70750	2257811.28	119563.11	163216.71	2614548.51	16875465.12
2022	7761504.78	3720202.35	75504	2494913.4	198789.3	541853.1	2082698.19	16875465.12

Annex IX.V Percentage Distribution of Area in LULUCF from 2001 to 2022

Year	Forest Land	Cropland	Grassland	Wetland	Settlement	Other land
2001	43.6554	26.3009	14.9117	1.6126	0.1763	13.3431
2002	43.5309	26.1997	14.7694	1.6046	0.1782	13.7172
2003	43.7931	25.9872	14.1979	1.6003	0.1846	14.2368
2004	43.9704	25.8230	14.2372	1.5900	0.1908	14.1887
2005	44.1277	25.6815	13.3211	1.5861	0.1941	15.0896
2006	44.2002	25.6077	13.6487	1.5843	0.1989	14.7602
2007	44.2350	25.5731	13.3426	1.5673	0.2026	15.0794
2008	44.2835	25.5630	13.6744	1.5362	0.2093	14.7336
2009	44.3320	25.5529	14.0062	1.5051	0.2159	14.3879
2010	44.3655	25.5329	14.4993	1.4758	0.2224	13.9040
2011	44.4203	25.4965	14.1031	1.4440	0.2271	14.3089
2012	44.4732	25.4384	14.0140	1.4251	0.2290	14.4203
2013	44.5262	25.3803	13.9248	1.4061	0.2309	14.5317
2014	44.5791	25.3222	13.8356	1.3871	0.2328	14.6431
2015	44.7260	25.1970	13.4967	1.3888	0.2459	14.9456
2016	44.8930	25.0150	14.5782	1.4280	0.2725	13.8133
2017	45.0479	24.7530	14.4910	1.4852	0.3159	13.9070
2018	45.2592	24.4389	14.4540	1.5258	0.5225	13.7997
2019	45.2558	24.2313	13.3323	1.5936	0.5284	15.0586
2020	46.2001	23.7477	13.0861	0.7217	0.6957	15.5487
2021	46.3449	23.1070	13.3793	0.7085	0.9672	15.4932
2022	45.9928	22.4925	14.7843	1.1780	3.2109	12.3416

Annex IX.VI Uncertainty analysis for LULUCF

Cropland Remaining Cropland				
	Biomass	Land Area Estimates	Activity Data	±10%
		Biomass Carbon Increment	Emission Factor	±75%
	Dead organic matter			-
	Soil carbon.	Aggregate land-use area statistics	Activity Data	±50%
Forest land Remaining Forest land				
	Biomass	Basic wood density	Emission Factor	10–40%
		Growing stock (non-industrialized countries)	Emission Factor	±30%
	Dead organic matter	-		
	Soil carbon	Soils with High Activity Clay (HAC)- C stocks for mineral soils	Activity Data	±90% (2x standard deviations)
Grassland remaining grassland				
	Biomass	Expansion Factor Uncertainties	Emission Factor	Low (2-6%)
		Activity Data (Area Estimates)	Activity Data	±50%
	Dead organic matter	Activity Data (Area Estimates)	Activity Data	±50%
	Soil carbon	Land-Use and Management Activity and Environmental Data	Activity Data	±50%
		Activity Data Uncertainties	Activity Data	±50%
Settlement remaining settlement				
	Biomass	-		
	Dead organic matter	-		
	Soil carbon	Land-use and management activities	Activity Data	±50%

Annex X. Waste

Annex X.I Supplementary Methodology

Solid waste disposal

Methane generation from decomposable DDOCm

The quantity of CH4 generated from decomposable waste material is estimated by multiplying the CH4 fraction in generated landfill gas with CH4/C molecular weight ratio (IPCC, 2006/2019).

CH_4 〖generated〗_T=DDOC_m decomp_T*F*16/12

Where,

CH4 generated = amount of CH4 generated from decomposable material

DDOCm decompT = DDOCm decomposed in year T, Gg

F = fraction of CH4, by volume, in generated landfill gas (fraction)

16/12 = molecular weight ratio CH4/C (ratio)

First order decay basics

The relationship between product and reactive material is constant in a first-order reaction (IPCC, 2006/2019). That is, the quantity of CH4 produced annually is not affected by the year the trash was placed in the SWDS. The amount of decaying material present at the site is the sole quantity that counts.

DDOC_m decomp_T=DDOCma_(T-1)*(1-e^(-k))

DDOCma_T=DDOCmd_T+(DDOCma_(T-1)*e^(-k))

Where,

T = inventory year

DDOCmaT = DDOCm accumulated in the SWDS at the end of year T, Gg

DDOCmaT-1 = DDOCm accumulated in the SWDS at the end of year (T-1), Gg

DDOCmdT = DDOCm deposited into the SWDS in year T, Gg

DDOCm decompT = DDOCm decomposed in the SWDS in year T, Gg

k = reaction constant, k = ln(2)/$t_{1/2}$ (y-1)
$t_{1/2}$ = half-life time (y)

Degradable organic carbon (DOC)

The organic carbon in garbage that can be broken down by biological processes is known as degradable organic carbon (DOC), and it is measured in grams of carbon per kilogram of waste. A weighted average of the degradable carbon content of the different components (waste types/materials) of the waste stream can be used to estimate the DOC in bulk waste. This estimate is dependent on the composition of the waste. The DOC is estimated using default carbon content values in the following equation (IPCC, 2006/2019).

$$\mathrm{DOC} = \sum_i (\mathrm{DOC}_i * W_i)$$

Where,
DOC = fraction of degradable organic carbon in bulk waste, Gg C/Gg waste
DOC_i = fraction of degradable organic carbon in waste type I
e.g., the default value for paper is 0.4 (wet weight basis)
W_i = fraction of waste type i by waste category

Domestic wastewater

CH_4 emissions from domestic wastewater treatment is calculated referring to the literature (IPCC, 2006/2019).

$$CH_4\mathrm{Emissions} = \sum_j \left[CH_4\mathrm{Emissions}_j\right] * [10^{-6}]$$

Where,
CH_4 Emissions = CH_4 emissions in inventory year, Gg CH_4/yr
CH_4 Emissions*j* = CH_4 emissions from treatment/discharge pathway or system, *j*, in inventory year, kg CH_4/yr
j = each treatment/discharge pathway or system
10^{-6} = conversion of kg to Gg

Choice of emission factors

Emission factor is calculated referring to the literature (IPCC, 2006/2019).

$$EF_j = B_O * MCF_j$$

Where,
EF_j = emission factor, kg CH4/kg BOD
j = each treatment/discharge pathway or system
B_o = maximum CH_4 producing capacity, kg CH_4/kg BOD
MCF_j = methane correction factor (fraction).

Choice of activity data

Total organics in wastewater in inventory year is calculated referring to the literature (IPCC, 2006/2019).

$$TOW = P * BOD * 0.001 * 365$$

Where,
TOW = total organics in wastewater in inventory year, kg BOD/yr
P = country population in inventory year, (person)
BOD = country-specific per capita BOD_5 in inventory year, g/person/day.
0.01 = conversion from grams BOD to kg BOD

Total organics in wastewater in inventory year by income group is calculated referring to the literature (IPCC, 2006/2019).

$$TOW_j = \sum_i \left[TOW * U_i * T_{ij} * I_j\right]$$

Where,
TOW_j = total organics in wastewater in inventory year, kg BOD/yr, for income group i and treatment/discharge pathway or system, j.
TOW = total organics in wastewater in inventory year, kg BOD/yr.
U_i = fraction of population in income group i in inventory year.
T_{ij} = degree of utilisation of treatment/discharge pathway or system, j, for each income group fraction
Ij = correction factor for additional industrial BOD discharged into treatment/discharge pathway or system j (for collected the default is 1.25, for uncollected the default is 1.00)

Organic component removed from wastewater (in the form of sludge) in aerobic treatment plants is calculated referring to the literature (IPCC, 2006/2019).

$$S_{aerobic} = (S_{mass} * K_{rem} * 1000)$$

Where,

$S_{aerobic}$ = organic component removed from wastewater (in the form of sludge) in aerobic treatment plants, kg BOD/yr
S_{mass} = amount of raw sludge removed from wastewater treatment as dry mass, tonnes/year
K_{rem} = sludge factor, kg BOD/kg sludge.
1000 = conversion factor for tonnes to kilograms

Organic component removed from wastewater (in the form of sludge) in septic systems is calculated referring to the literature (IPCC, 2006/2019).

$$S_{septic} = TOW_{septic} * F * 0.5$$

Where,

S_{septic} = organic component removed from wastewater (in the form of sludge) in septic systems, kg BOD/yr
TOW_{septic} = total organics in wastewater in septic systems inventory year, kg BOD/yr

F = fraction of the population managing their septic tank in compliance with the sludge removal instruction of their septic system
0.5 = fraction of organics in wastewater removed in sludge when septic tank is managed in accordance with sludge removal instructions

Total organics in the treated wastewater effluent discharged to aquatic environments in inventory year is calculated referring to the literature (IPCC, 2006/2019).

$$TOW_{EFFtreat} = \sum_j [TOW * T_j * (1 - TOW_{REM,j})]$$

Where,
$TOW_{EFFtreat}$ = total organics in the treated wastewater effluent discharged to aquatic environments in inventory year, kg BOD/yr
TOW = total organically degradable material in domestic wastewater in inventory year, kg BOD/yr.
T_J = degree of utilisation of treatment system j in inventory year.
j = each wastewater treatment type used in inventory year
$TOW_{REM,j}$ = fraction of total wastewater organics removed during wastewater treatment per treatment type j.

N2O emissions from domestic wastewater effluent in inventory year is calculated referring to the literature (IPCC, 2006/2019).

$$N_2O_{Effluent,DOM} = N_{Effluent,DOM} * EF_{Effluent} * \frac{44}{28}$$

Where,

$N_2O_{EFFLUENT,DOM}$ = N_2O emissions from domestic wastewater effluent in inventory year, kg N_2O/yr
NEFFLUENT,DOM = nitrogen in the effluent discharged to aquatic environments, kg N/yr.
$EF_{EFFLUENT}$ = emission factor for N_2O emissions from wastewater discharged to aquatic systems, kg N_2O-N/kg N
The factor 44/28 is the conversion of kg N_2O-N into kg N_2O

Nitrogen in domestic wastewater (TNDOM)

Total annual amount of nitrogen in domestic wastewater for treatment pathway is calculated referring to the literature (IPCC, 2006/2019).

$$TN_{DOM\_j} = (P_{treatment\_j} * Protein * F_{NPR} * N_{HH} * F_{NON-CON} * F_{IND-COM})$$

Where,

TN_{DOM_j} = total annual amount of nitrogen in domestic wastewater for treatment pathway j, kg N/yr
$P_{treatment\_j}$ = human population who are served by the treatment pathway j, person/yr

Protein = annual per capita protein consumption, kg protein/person/yr
F_{NPR} = fraction of nitrogen in protein, default = 0.16 kg N/kg protein
$F_{NON\text{-}CON}$ = factor for nitrogen in non-consumed protein disposed in sewer system, kg N/kg N.
$F_{IND\text{-}COM}$ = factor for industrial and commercial co-discharged protein into the sewer system, kg N/kg N
N_{HH} = additional nitrogen from household products added to the wastewater, default is 1.1

Annual per capita protein supply is calculated referring to the literature (MoAD, 1994-2022).

$$\text{Protein} = \text{Protein}_{\text{Supply}} * \text{FPC}$$

Where,

$\text{Protein}_{\text{Supply}}$ = annual per capita protein supply, kg protein/person/yr
FPC = Fraction of protein consumed.
Total nitrogen in the wastewater effluent discharged to aquatic environments in inventory year is calculated referring to the literature (IPCC, 2006/2019).
Nitrogen in wastewater effluent (NEFFLUENT,DOM)

$$N_{\text{Effluent,DOM}} = \sum_j \left[\left(TN_{\text{DOM}} * T_j \right) * \left(1 - N_{\text{REM},j} \right) \right]$$

Where,

$N_{\text{Effluent,DOM}}$ = total nitrogen in the wastewater effluent discharged to aquatic environments in inventory year, kg N/yr
TN_{DOM} = total nitrogen in domestic wastewater in inventory year, kg N/yr.
T_j = degree of utilisation of treatment system *j* in inventory year.
j = each wastewater treatment type used in inventory year
N_{REM} = fraction of total wastewater nitrogen removed during wastewater treatment per treatment type j.

Industrial wastewater

Total organically degradable material in wastewater for industry is calculated referring to the literature (IPCC, 2006/2019).

Choice of activity data

$$TOW_i = P_i * W_i * COD_i$$

Where,

TOW_i = total organically degradable material in wastewater for industry i, kg COD/yr
i = industrial sector
P_i = total industrial product for industrial sector i, t/yr
W_i = wastewater generated, m3/t product

COD_i = chemical oxygen demand (industrial degradable organic component in wastewater), kg COD/m^3

N2O emissions from industrial wastewater effluent in inventory year is calculated referring to the literature (IPCC, 2006/2019).

$$N_2O\ Effluent_{IND} = N_{Effluent,IND} * EF_{Effluent} * \frac{44}{28}$$

Where,

$N_2OEffluentIND$ = N_2O emissions from industrial wastewater effluent in inventory year, kg N_2O/yr
$N_{Effluent,IND}$ = nitrogen in the industrial wastewater effluent discharged to aquatic environments, kg N/yr.
$EF_{Effluent}$ = emission factor for N_2O emissions from wastewater discharged to aquatic systems, kg N_2O-N/kg N
The factor 44/28 is for the conversion of kg N_2O-N into kg N_2O.

Choice of activity data
For each selected sector estimate total N in the industrial wastewater (TNIND) (IPCC, 2006/2019).

$$TN_{INDi} = P_i * W_i * TN_i$$

Where,

TN_{INDi} = total nitrogen in wastewater entering treatment for industry i, kg TN/yr
i = industrial sector
P_i = total industrial product for industrial sector i, t/yr
W_i = wastewater generated for industrial sector i, m^3/t product
TN_i = total nitrogen in untreated wastewater for industrial sector i, kg TN/m^3

Nitrogen in wastewater effluent (NEFFLUENT,IND)

Total annual amount of nitrogen in the industrial wastewater effluent is calculated referring to the literature (IPCC, 2006/2019).

$$N_{Effleunt,IND} = \sum_j \left[TN_{INDi} * T_j * \left(1 - N_{REM,j}\right)\right]$$

Where,
$N_{Effluent,IND}$ = total annual amount of nitrogen in the industrial wastewater effluent, kg N/yr
TN_{INDi} = total nitrogen in wastewater entering treatment for industry i, kg TN/yr
T_j = degree of utilisation of treatment system j in inventory year.
j = each wastewater treatment type used in inventory year
$N_{REM,j}$ = fraction of total wastewater nitrogen removed during wastewater treatment per treatment type j.

Annex X.II Waste generation rate of urban areas of Nepal

Year	Population of urban areas	MSWGR (kg/person/day)	MSWGR (kg/person/yr)	Total MSW generated (Gg)
1994	2,056,946	0.25	91	188
1995	2,193,710	0.25	91	200
1996	2,339,567	0.25	91	213
1997	2,495,123	0.25	91	228
1998	2,661,021	0.25	91	243
1999	2,837,949	0.25	91	259
2000	3,026,641	0.25	91	276
2001	3,227,879	0.25	91	295
2002	3,328,461	0.25	91	304
2003	3,432,177	0.25	91	313
2004	3,539,124	0.26	95	336
2005	3,649,405	0.26	95	346
2006	3,763,121	0.26	95	357
2007	3,880,382	0.27	99	382
2008	4,001,295	0.29	99	394
2009	4,125,977	0.29	107	442
2010	4,254,544	0.29	107	456
2011	4,523,821	0.29	107	485
2012	5,161,504	0.32	116	597
2013	5,889,076	0.34	123	724
2014	6,719,207	0.36	130	875
2015	7,666,355	0.38	130	998
2016	8,747,013	0.40	138	1208
2017	9,980,003	0.40	146	1457
2018	11,386,796	0.40	146	1662
2019	12,991,892	0.40	146	1897
2020	14,823,245	0.40	146	2164
2021	19,296,788	0.40	146	2817
2022	22,016,886	0.40	146	3214

Annex X.III Waste disposal amount and composition of urban areas of Nepal

Year	Total MSW disposed at SWDS (%)	Total MSW disposed at SWDS (Gg)	Organic waste (%)	Paper (%)	Rubber/ leather (%)	Wood (%)	Plastic (%)	Cloths (%)
1994	62.3	117	65.6	9.0	1.0	0.0	9.0	0.0
1995	62.3	125	65.6	9.0	1.0	0.0	9.0	0.0
1996	62.3	133	65.6	9.0	1.0	0.0	9.0	0.0
1997	62.3	142	65.6	9.0	1.0	0.0	9.0	0.0
1998	62.3	151	65.6	9.0	1.0	0.0	9.0	0.0
1999	62.3	161	65.6	9.0	1.0	0.0	9.0	0.0
2000	62.3	172	65.6	9.0	1.0	0.0	9.0	0.0
2001	62.3	184	65.6	9.0	1.0	0.0	9.0	0.0
2002	62.3	189	65.6	9.0	1.0	0.0	9.0	0.0
2003	62.3	195	65.6	9.0	1.0	0.0	9.0	0.0
2004	62.3	209	63.6	10.0	1.0	0.0	10.0	0.0
2005	62.3	216	63.6	10.0	1.0	0.0	10.0	0.0
2006	62.3	222	63.6	10.0	1.0	0.0	10.0	0.0
2007	62.3	238	61.6	11.0	1.0	0.0	11.0	0.0
2008	62.3	246	58.8	13.5	1.0	2.1	13.5	2.3
2009	62.3	275	58.8	13.5	1.0	2.1	13.5	2.3
2010	62.3	284	58.8	13.5	1.0	2.1	13.5	2.3
2011	62.3	302	58.8	13.5	1.0	2.1	13.5	2.3
2012	62.3	372	56.0	16.0	1.0	4.3	16.0	4.5
2013	62.3	451	56.0	16.0	1.0	4.3	16.0	4.5
2014	62.3	545	56.0	16.0	1.0	4.3	16.0	4.5
2015	62.3	622	56.0	16.0	1.0	4.3	16.0	4.5
2016	62.3	752	56.0	16.0	1.0	4.3	16.0	4.5
2017	62.3	908	56.0	16.0	1.0	4.3	16.0	4.5
2018	62.3	1036	56.0	16.0	1.0	4.3	16.0	4.5
2019	62.3	1182	56.0	16.0	1.0	4.3	16.0	4.5
2020	62.3	1348	56.0	16.0	1.0	4.3	16.0	4.5
2021	62.3	1755	56.0	16.0	1.0	4.3	16.0	4.5
2022	62.3	2003	56.0	16.0	1.0	4.3	16.0	4.5

Annex X.IV Total amount of waste composted

Year	Total organic waste (Gg)	Total organic waste composted (Gg)
1994	123.1	6.2
1995	131.3	6.6
1996	140.0	7.0
1997	149.4	7.5
1998	159.3	8.0
1999	169.9	8.5
2000	181.2	9.1
2001	193.2	9.7
2002	199.2	10.0
2003	205.5	10.3
2004	220.3	11.0
2005	220.3	11.0
2006	227.1	11.4
2007	235.6	11.8
2008	242.9	12.1
2009	259.9	13.0
2010	268.0	13.4
2011	285.0	14.2
2012	334.4	16.7
2013	405.4	20.3
2014	489.8	24.5
2015	558.8	27.9
2016	676.4	33.8
2017	816.0	40.8
2018	931.0	46.5
2019	1062.2	53.1
2020	1211.9	60.6
2021	1577.7	78.9
2022	1800.1	90.0

Annex X.V Total amount of clinical waste incinerated

Year	Clinical waste incinerated (Gg)
1994	0.12
1995	0.16
1996	0.19
1997	0.34
1998	0.44
1999	0.48
2000	0.48
2001	0.52
2002	0.52
2003	0.52
2004	0.58
2005	0.58
2006	0.73
2007	0.77
2008	0.77
2009	0.77
2010	0.77
2011	0.80
2012	0.84
2013	0.84
2014	0.88
2015	0.88
2016	0.88
2017	0.94
2018	0.95
2019	0.95
2020	1.03
2021	1.06
2022	1.06

Annex X.VI Total amount of waste generation in Nepal

Year	Population of Nepal	Urban population	Rural population	MSWGR (kg/person/yr), Urban	MSWGR (kg/person/yr), Rural
1994	19,780,952	2,056,946	17,724,006	91	62.05
1995	20,230,596	2,193,710	18,036,886	91	62.05
1996	20,690,462	2,339,567	18,350,894	91	62.05
1997	21,160,781	2,495,123	18,665,658	91	62.05
1998	21,641,790	2,661,021	18,980,770	91	62.05
1999	22,133,734	2,837,949	19,295,785	91	62.05
2000	22,636,860	3,026,641	19,610,219	91	62.05
2001	23,151,423	3,227,879	19,923,544	91	62.05
2002	23,465,807	3,328,461	20,137,347	91	62.05
2003	23,784,461	3,432,177	20,352,284	91	62.05
2004	24,107,441	3,539,124	20,568,317	95	62.05
2005	24,434,808	3,649,405	20,785,403	95	62.05
2006	24,766,620	3,763,121	21,003,499	95	62.05
2007	25,102,938	3,880,382	21,222,556	99	62.05
2008	25,443,823	4,001,295	21,442,527	99	62.05
2009	25,789,337	4,125,977	21,663,360	107	62.05
2010	26,139,543	4,254,544	21,884,999	107	62.05
2011	26,494,504	4,523,821	21,970,683	107	62.05
2012	26,750,123	5,161,504	21,588,619	116	62.05
2013	27,008,208	5,889,076	21,119,132	123	62.05
2014	27,268,784	6,719,207	20,549,576	130	62.05
2015	27,531,873	7,666,355	19,865,518	130	62.05
2016	27,797,500	8,747,013	19,050,487	138	62.05
2017	28,065,691	9,980,003	18,085,688	146	62.05
2018	28,336,469	11,386,796	16,949,673	146	62.05
2019	28,609,859	12,991,892	15,617,967	146	62.05
2020	28,885,887	14,823,245	14,062,642	146	62.05
2021	29,164,578	19,296,788	9,867,790	146	62.05

Annex X.VII Total amount of waste burnt by composition in Nepal

Year	Total food/organic waste burnt (Gg)	Total paper burnt (Gg)	Total plastic burnt (Gg)	Total rubber burnt (Gg)	Total textiles burnt (Gg)	Total wood burnt (Gg)
1994	58.0	10.0	10.0	1.1	0.0	0.0
1995	59.4	10.2	10.2	1.1	0.0	0.0
1996	60.9	10.5	10.5	1.2	0.0	0.0
1997	62.4	10.7	10.7	1.2	0.0	0.0
1998	64.0	11.0	11.0	1.2	0.0	0.0
1999	65.6	11.3	11.3	1.3	0.0	0.0
2000	67.3	11.5	11.5	1.3	0.0	0.0
2001	69.0	11.8	11.8	1.3	0.0	0.0
2002	70.0	12.0	12.0	1.3	0.0	0.0
2003	71.0	12.2	12.2	1.4	0.0	0.0
2004	70.4	13.9	13.9	1.4	0.0	0.0
2005	71.5	14.1	14.1	1.4	0.0	0.0
2006	72.5	14.3	14.3	1.4	0.0	0.0
2007	71.9	16.1	16.1	1.5	0.0	0.0
2008	69.7	20.0	20.0	1.5	2.7	0.5
2009	72.1	20.7	20.7	1.5	2.8	0.5
2010	73.2	21.0	21.0	1.6	2.8	0.5
2011	74.6	21.4	21.4	1.6	2.9	0.5
2012	74.5	26.6	26.6	1.7	6.0	1.1
2013	78.2	28.0	28.0	1.7	6.3	1.1
2014	82.7	29.6	29.6	1.8	6.7	1.2
2015	85.8	30.7	30.7	1.9	6.9	1.2
2016	91.9	32.9	32.9	2.1	7.4	1.3
2017	99.2	35.5	35.5	2.2	8.0	1.4
2018	104.4	37.3	37.3	2.3	8.4	1.5
2019	110.2	39.4	39.4	2.5	8.9	1.6
2020	116.8	41.8	41.8	2.6	9.4	1.7
2021	131.9	47.2	47.2	2.9	10.7	1.9
2022	141.4	50.5	50.5	3.2	11.4	2.0

Domestic WWT plants

Year	Population	Sludge removed (kg BOD)	Flaring (kg CH4)	Energy use (kg CH4)
1994	-	-	-	-
1995	-	-	-	-
1996	-	-	-	-
1997	2150	3531	-	-
1998	2150	3531	-	-
1999	2150	3531	-	-
2000	2150	3531	-	-
2001	80974	43448	-	-
2002	86165	102910	-	-
2003	100865	136066	-	-
2004	106488	136241	-	-
2005	112506	136574	-	-
2006	119306	136911	-	-
2007	126243	140255	-	-
2008	135451	161709	-	-
2009	143105	162056	-	-
2010	151234	162406	-	-
2011	159264	160639	-	-
2012	167854	158960	-	-
2013	177037	157366	-	-
2014	186849	155851	-	-
2015	347332	156287	-	-
2016	362507	154920	-	-
2017	378533	153621	-	-
2018	395741	153374	-	-
2019	413882	153130	-	-
2020	483078	152888	-	-
2021	603567	2091809	2350	38441
2022	608178	2091572	1477	32436

Annex X.VIII Industrial WWT plants (Hetauda)

Year	Alcohol refining (tonnes)	Beer & Meat (tonnes)	Dairy products (tonnes)	Meat & poultry (tonnes)	Organic chemicals (tonnes)	Plastics & resins (tonnes)	Pulp & paper (tonnes)	Soap & detergent (tonnes)	Starch production (tonnes)	Veg, fruit & juice (tonnes)
1994	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-
2001	9279	16212	27116	20952	82666	19229	6648	26594	1108	8865
2002	9279	16212	27116	20952	82666	19229	6648	26594	1108	8865
2003	15420	26941	45061	34818	137376	31954	11049	44194	1841	14731
2004	15420	26941	45061	34818	137376	31954	11049	44194	1841	14731
2005	15420	26941	45061	34818	137376	31954	11049	44194	1841	14731
2006	15420	26941	45061	34818	137376	31954	11049	44194	1841	14731
2007	15420	26941	45061	34818	137376	31954	11049	44194	1841	14731
2008	15420	26941	45061	34818	137376	31954	11049	44194	1841	14731
2009	15420	26941	45061	34818	137376	31954	11049	44194	1841	14731
2010	15420	26941	45061	34818	137376	31954	11049	44194	1841	14731
2011	15420	26941	45061	34818	137376	31954	11049	44194	1841	14731
2012	15420	26941	45061	34818	137376	31954	11049	44194	1841	14731
2013	15420	26941	45061	34818	137376	31954	11049	44194	1841	14731
2014	15420	26941	45061	34818	137376	31954	11049	44194	1841	14731
2015	22027	38486	64371	49738	196243	45647	15783	63132	2631	21044
2016	22027	38486	64371	49738	196243	45647	15783	63132	2631	21044
2017	22027	38486	64371	49738	196243	45647	15783	63132	2631	21044
2018	22027	38486	64371	49738	196243	45647	15783	63132	2631	21044
2019	22027	38486	64371	49738	196243	45647	15783	63132	2631	21044
2020	22027	38486	64371	49738	196243	45647	15783	63132	2631	21044
2021	22027	38486	64371	49738	196243	45647	15783	63132	2631	21044
2022	22027	38486	64371	49738	196243	45647	15783	63132	2631	21044

Annex X.IX Emission Factor for Waste Sector

Waste category	EFs	Sources
Incineration/MSW open burning	CH4 (g CH_4/kg)	IPCC, 1996/2006
	N_2O (g N_2O/kg)	IPCC, 1996/2006
Biological Treatment of SW	CH_4 (kg/Gg)	IPCC, 1996/2006
	N_2O (kg/Gg)	IPCC, 1996/2006
Waste water treatment	CH4 (kg CH_4/kg BOD)	IPCC, 1996/2006
	N2O (kg N_2O/person/year)	IPCC, 1996/2006

Annex X.X Trend of emission from waste sector(Gg CO_2eq)

Years	Solid Waste Disposal	Biological Treatment of Solid Waste	Incineration and Open Burning of Waste	Wastewater Treatment and Discharge
1994	30.85101	1.065372	32.476476	380.49178
1995	54.2417	1.1362815	33.185742	404.3657
1996	72.74339	1.21065	34.158723	430.01163
1997	88.09546	1.2919365	34.940747	457.96813
1998	101.4796	1.376682	35.929238	487.87277
1999	113.7035	1.4683455	36.922009	520.05522
2000	125.3248	1.566927	37.667105	554.93698
2001	136.7334	1.670697	38.64596	700.24422
2002	148.2076	1.7277705	39.252525	741.37675
2003	158.2907	1.788303	39.904568	809.43835
2004	167.482	1.923204	43.308704	843.99443
2005	177.6475	1.9283925	43.91527	865.63512
2006	185.8247	1.9941135	44.624019	888.97742
2007	193.0017	2.0754	48.252289	917.73819
2008	202.0788	2.1463095	56.930408	938.95168
2009	211.8589	2.303694	59.098214	949.97516
2010	230.3767	2.383251	59.99417	932.09618
2011	247.2166	2.4645375	60.880908	991.004
2012	262.9612	2.929773	73.093352	1048.0448
2013	296.3416	3.5990895	76.944663	1261.8723
2014	346.187	4.406766	81.574019	1373.1347
2015	413.1076	5.095107	85.065641	1594.463
2016	488.8909	6.246954	91.636666	1755.9504
2017	587.6805	7.637472	99.578998	1931.684
2018	711.6931	8.8290975	105.52663	2143.4989
2019	847.1283	10.207509	112.36315	2371.3183
2020	998.1271	11.8003785	119.98649	2683.4872
2021	1168.731	13.6440255	128.9677	2976.621
2022	1363.106	13.842918	130.38988	3306.9521

Annex X.XI Recalculation and GHG emission from waste sector 1994-2022

Years	CO_2	CH_4	N_2O	CO_2-eq. National Communications
1994	16.364	299.04	129.48	584.66
1995	16.708	338.21	138.01	
1996	17.23	373.77	147.12	
1997	17.625	407.63	157.04	
1998	18.164	441.1	167.39	
1999	18.686	475.03	178.43	
2000	19.007	510.29	190.19	
2001	19.516	654.96	202.82	784.07
2002	19.837	700.99	209.74	
2003	20.182	772.33	216.91	
2004	22.937	809.35	224.42	
2005	23.258	833.81	232.06	
2006	23.658	857.79	239.97	
2007	26.592	886.2	248.28	
2008	33.306	909.53	257.27	
2009	34.606	922.5	266.13	
2010	35.111	914.54	275.2	
2011	35.627	981.36	284.58	949.1
2012	44.695	1013.3	329.01	
2013	47.033	1211.7	380	
2014	49.857	1316.5	438.98	
2015	51.999	1538.6	507.12	
2016	55.998	1700.7	585.98	
2017	60.828	1888.6	677.2	
2018	64.471	2122.7	782.35	
2019	68.63	2368.5	903.92	
2020	73.287	2695.6	1044.5	
2021	78.78	3001.9	1207.3	
2022	79.623	3340.7	1394	

Annex X.XII Uncertainty in GHG Emissions from Category 4A - Solid Waste Disposal

Parameter	Uncertainty
Total quantity of MSW generated	-30%, +30%
Fraction of MSW sent to SWDS	-30%, +30%
Waste composition	-30%, +30%
Degradable organic carbon (DOC)	-20%, +20%
Fraction of DOC dissimilated	-20%, +20%
CH_4 generation rate constant (average for combined waste)	-27%, +27%
Delay time	-33%, +33%
Fraction of CH_4 in developed gas	-5%, +5%
Oxidation factor	0%
Methane correction factor – managed anaerobic SWDS	10%, 0%
Methane correction factor – uncategorized SWDS	-50%, +60%

Annex X.XIII Uncertainty in GHG Emissions from Category 4C – Incineration and Open Burning of Waste

Parameter	Uncertainty
Total quantity of MSW generated	-30%, +30%
Fraction of MSW open-burnt	-30%, +30%
Waste composition	-30%, +30%
Combined CO_2 emission factors for open burning of waste	-40%, +40%
CH_4 emission factor for open burning of waste	-100%, +100%
N_2O emission factor for open burning of waste	-100%, +100%

Annex X.XIV Uncertainty in GHG Emissions from Category 4D – Wastewater Treatment and Discharge.

Parameter	Uncertainty
Population	-5%, +5%
Per capita protein consumption	-10%, +10%

Nitrogen removed with sludge	0%
Fraction of nitrogen in protein	-6%, +6%
Factor for non-consumed protein added to the wastewater	-9%, +27%
Factor for industrial and commercial co-discharged protein	-20%, +20%
Factor to account for losses of nitrogen prior to discharge	-50%, +50%
N_2O emission factor for effluent	-90%, +1400%
Per capita BOD	-30%, +30%
Correction factor for additional industrial BOD discharged into sewers	-20%, +20%
Degree of utilization of treatment method	-50%, +50%
Organic components removed as sludge	0%
Annual mass of CH_4 recovered and flared	0%
Maximum CH_4 producing capacity	-30%, +30%
Methane correction factors from sewerage and direct disposal	-50%, +50%

Annex XI. Scenario Projection Parameters

Annex XI.I Projection and Scenario analysis parameters

- **Demography**

Population Growth rate	2011-2021	0.92% per annum
Urban Population	2021	66.1% of national population
Urban Population Growth rate		1.46%

(CBS, 2022, 2012; NSO, 2024)

- **Economic parameters**

GDP (in constant price)

	National GDP	Agriculture	Industry	Services
	Billion NPR	**Billion NPR**	**Billion NPR**	**Billion NPR**
1994	785	283	111	332
1995	812	282	115	349
1996	856	294	125	368
1997	899	306	133	386
1998	926	309	136	409
1999	967	318	144	430
2000	1027	334	156	457
2001	1076	348	161	483
2002	1077	359	163	475
2003	1120	371	168	492
2004	1172	389	170	526
2005	1213	402	175	543
2006	1254	409	183	574
2007	1297	413	190	600

	National GDP	Agriculture	Industry	Services
	Billion NPR	**Billion NPR**	**Billion NPR**	**Billion NPR**
2008	1376	437	194	644
2009	1438	451	192	682
2010	1508	460	200	722
2011	1559	480	209	747
2012	1632	506	221	780
2013	1690	512	227	814
2014	1791	535	244	863
2015	1862	542	249	910
2016	1870	541	239	920
2017	2038	569	280	997
2018	2194	584	309	1090
2019	2340	614	331	1164
2020	2284	629	318	1111
2021	2395	647	340	1163
2022	2530	662	377	1225
Average Growth rate	4.21%	3.09%	4.44%	4.73%

(World Bank, 2023)

- **GDP growth rates (in % per annum)**
  - **Government target**

	Actual of	Estimated	Targets of 16th Plan					Average
	2023	2024	2025	2026	2027	2028	2029	
Primary Sector	2.7	3	4.3	4	4	3.9	4.3	4.1
Secondary Sector	1.4	1.2	10.3	10.8	11.7	11.5	12.4	11.3
Service Sector	2.4	4.5	5.8	6.7	8	8.5	7.2	7.2
National GDP (at basic price)	2.3	3.5	6	6.6	7.6	7.9	7.3	7.1

(NPC, 2024)

- **Historical trend**

Percent Growth from Previous Year						
Branch	2025	2030	2035	2040	2045	2050
National GDP	2.5	2.2	2.0	1.8	1.7	1.5
Agriculture GVA (Primary Sector)	2.1	1.9	1.7	1.6	1.5	1.4
Manufacturing (Secondary Sector)	2.4	2.1	1.9	1.8	1.6	1.5
Services Sector	2.6	2.3	2.1	1.9	1.7	1.6

Estimated in LEAP based on historical GDP

Technical expert group

Shankar Adhikari, REDD Implementation Centre
Sushil Kumar Sharma, National Statistics Office
Dr. Ramesh Prasad Sapkota, Tribhuvan University
Surya Dev Gupta, Water and Energy Commission Secretariat
Dr. Bimala Devi Devkota, National Academy for Science and Technology
Bimal Kumar Acharya, Forest Research and Training Centre
Khagendra Bahadur Basnet, Ministry of Industry, Commerce and Supplies
Tejendra Regmi, Ministry of Energy, Water Resources and Irrigation
Bishnu Hari Devkota, Ministry of Agriculture and Livestock Development
Munaka Neupane, Ministry of Physical Infrastructure and Transport
Jaya Ram Upreti, Ministry of Federal Affairs and General Administration
Harinarayan Belbase, National Planning Commission
Pratima KC, Alternative Energy Promotion Centre
Dr. Basanta Raj Adhikari, Institute of Engineering
Kiran Kumar Pokharel, CCMD, MoFE
Khem Raj Kafle, CCMD, MoFE
Santa Kumar Maharjan Arati Jha, Ratna Binod Subedi, MoFE

National consultants

National GHG inventory: Team Leader (Late Prof. Dr. Amrit Man Nakarmi), Utsav Shree Rajbhandari, Dr. Chet Raj Upreti, Khem Raj Dahal, Dr. Nabin Bhattarai, Dr. Bhupendra Das. Sanjay Rajbhandari, Jyotsana Dhungana, Sristi Khanal, Rashika Pandit. Organization: ADAPT-Nepal JV ICDPI
Adaptation Reporting: Ngamindra Raj Dahal (Team Leader), Raju Laudari, Saurav Shrestha, Bimal Ghimire, Sami Kunwar, Nagendra Bastakoti Organization: Inclusive Consultant Pvt. Ltd, Center for Climate and Environment Research
Support Received: Ganesh Raj Acharya (Team Leader), Pravakar Pradhan, Nabaraj Dahal, Sunil Prasad Lohani, Prakash Chandra Tara, Ram P. Acharya Organization: Practical Solution Consultancy Nepal Pvt. Ltd.

Government agencies:

Ministry of Finance, Ministry of Home Affairs; Ministry of Agriculture and Livestock Development; Ministry of Energy, Water Resources and Irrigation; Ministry of Industry, Commerce and Supplies; Ministry of Physical Infrastructure and Transport; Ministry of Urban Development; Ministry of Federal Affairs and General Administration, Ministry of Water Supply, and Ministry of Health and Population
National Planning Commission, Water and Energy Commission Secretariat, Solid Waste Management Technical Support Centre, Alternative Energy Promotion Centre, Nepal Agricultural Research Council, Nepal Rastra Bank, Nepal Electricity Authority, and National Statistics Office.

International agencies:

WWF Nepal/CBIT Project

United States Environmental Protection Agency (US EPA) staff, Keyle Horton and Dr. Yasmine Farhat (AAAS S&TP Fellow), as well as the US EPA support team, particularly Kara Edquist, John Watterson, Chris Thorpe, Céline Guéguen, Ross Hunter, Sabino Del Vento, Peter Brown, Charis Evans, Serena Churchill, Sina Wartmann, Leandro Buendia, Paelina DeStephano, Gokul Chandramouli Iyer, and Anastasiia Zagoruichyk, for technical advice on GHG inventory.

Food and Agriculture Organization of the United Nations (FAO), through the Global Capacity Building towards Enhanced Transparency (CBIT-AFOLU+) for inputs on AFOLU and Adaptation provided by Alessandro Francesco, Viviane Umulisa, Pedro Muradás Montesinos, Janek Toepper, Lordanis Tzamtzis, and Mirella Salvatore.

Marija Kono from the SilvaCarbon program.