AN ASSESSMENT OF CARBON SEQUESTRATION AND EMISSION IN GANDAKI PROVINCE

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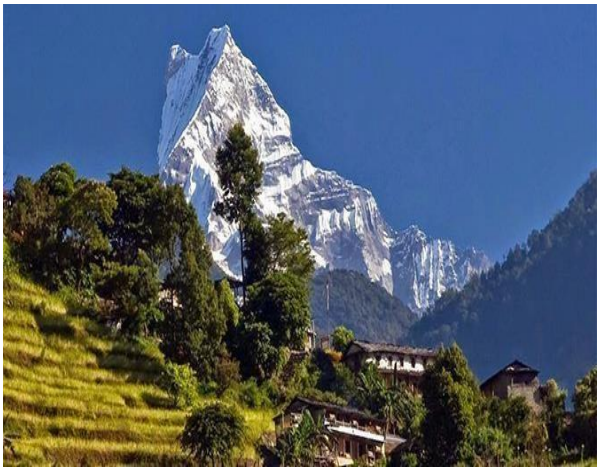

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Provincial Government

Ministry of Forest, Environment and Soil Conservation

Forest Research and Training Centre

Pokhara, Kaski, Gandaki Province

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Thank You.

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ACRONYMS AND ABBREVIATIONS

AFOLU	Agriculture, Forestry, and Other Land Use
ATP	Aviation Turbine Fuel
CBS	Central Bureau of Statistics
CKD	Cement Kiln Dust
DoI	Department of Industries
DoTM	Department of Transport Management
EF	Emission Factor
FRL	Forest Reference Level
FRTC	Forest Research and Training Center
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HWP	Harvested Wood Products
INC	Initial National Communication
ISW	Industrial Solid Waste
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LENS	Lumbini Environmental Services Pvt. Ltd.
LPG	Liquefied Petroleum Gas
MoF	Ministry of Finance
MoPE	Ministry of Population and Environment
MoPID	Ministry of Physical Infrastructure Development
MoSTE	Ministry of Science, Technology, and Environment
MPFS	Master Plan for the Forestry Sector
MSW	Municipal Solid Waste
NDC	Nationally Determined Contribution
NOC	Nepal Oil Corporation
SNC	Second National Communication
TEPC	Trade Export Promotion Center
TNC	Third National Communication
UNDESA	United Nations Department of Economic and Social Affairs
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank
WECS	Water and Energy Commission Secretariat

Chemical Compound

CaO	Calcium oxide
CO	Carbon monoxide
CO2	Carbon dioxide
CO2-eq	Carbon dioxide equivalent

Units

Gg	Gigagram
kg	kilogram
yr	year
t	tonnes
TJ	Terajoule

EXECUTIVE SUMMARY

This report presents a detail status of carbon Sequestration and carbon emission (CO_2) in Gandaki Province from four sectors; Energy, Industrial processes and product use (IPPU); Agriculture, Forestry, and other Land Use (AFOLU); and Waste. IPCC guidelines 2006, Initial National Communication (INC), Second National Communication (SNC) and Third National Communication (TNC) were considered as the guiding documents. Due to a lack of detailed disaggregated data for many activities in the sectors, this analysis relied heavily on the Tier 1 methodology of the 2006 IPCC guidelines. Tier 2 and Tier 3 were also considered based on data availability. To collect relevant data and information, field visits, direct observation, key informant interviews were done in several areas of Gandaki Province.

According to our findings, total carbon emissions in Gandaki Province were 4253.42Gg CO2-eq, whereas total carbon sequestration was 2330.79Gg CO2-eq, indicating that emissions outweighed sequestration by 1923Gg. Summary of carbon emission and sequestration in Gandaki Province is presented below.

S.N.	Sectors and Sub-Sectors	Emission of CO_2-eq (Gg)	Sequestration of CO_2-eq (Gg)
1	Energy Sector	2,142.42	-
1a	Transportation sub-sector	705.6	-
1b	Residential sub-sector	1,183.78	-
1c	Agricultural sub-sector	32.88	-
1d	Commercial sub-sector	118.8	-
1e	Manufacturing Industries	101.9	-
2	IPPU Sector	771.16	-
3	AFOLU Sector	1339.8	2330.7
4	Waste Sector	0.07	-
Total		**4253.45**	**2330.79**

Energy Sector: Among the emitted carbon, Energy sector contributed 2142.42Gg/yr (51% of total carbon emitted from Gandaki Province). The total estimated carbon emission from transportation, residential, agriculture, manufacturing industries and commercial sectors were 705.06 Gg, 1,183.75Gg, 32.88Gg, 101.9 Gg and 118.8Gg, respectively.

IPPU Sector: The total estimated CO_2 emission from this sector was estimated to be 771.16Gg (approximately 18% contribution from cement production).

AFOLU Sector: The total estimated amount of CO_2 emission (including fire) estimated from this sector was 1339.8Gg (32% of the total emission) of CO_2-eq and the total amount of CO_2 sequestration was 2330.7 Gg of CO_2-eq.

Waste Sector: The total estimated CO_2 emission from the waste sector is 0.07 Gg (0.002%) of the total emission).

At present, carbon sequestration is less than carbon emission, but adoption of ways to increase carbon sequestration would definitely help Gandaki Province be a Carbon-Neutral Province in the near future.

सारांश

कार्बन उत्सर्जन र संचितिकरण अहिले संसारको लागि दुई प्रमुख मुद्दाको रुपमा उठेका छन्। कार्बन उत्सर्जन कम गर्ने र संचितिकरणलाई बढाउने अभियान र उद्देश्यलाई साकार पार्न सर्वप्रथम कुनै पनि ठाउँमा कार्बन उत्सर्जन र संचितिकरणको अवस्था पत्ता लगाउन अत्यावश्यक हुन्छ। यही अभिप्रायका साथ गण्डकी प्रदेशको वन अनुसन्धान तथा तालिम केन्द्र (FRTC) को संयोजनमा लुम्बिनी इन्भाइरोमेन्टल सर्भिसेस प्रा.लि.ले (LENS) गण्डकी प्रदेशमा कार्बन उत्सर्जन र कार्बन संचितिकरणको अवस्थाको बारे यस प्रतिवेदन तयार गरेको छ।

यस प्रतिवेदनमा गण्डकी प्रदेश भित्र ऊर्जा क्षेत्र, औद्योगिक प्रक्रिया र उत्पादन प्रयोग क्षेत्र, कृषि, वन तथा अन्य भूमि प्रयोग क्षेत्र र फोहोरमैला क्षेत्रको कार्बन उत्सर्जन र संचितिकरणको विस्तृत विवरण प्रस्तुत गरिएको छ। जलवायु परिवर्तनका लागि अन्तर सरकारी समूह(आई.पि.सी.सी.) को निर्देशिका, २००६, पहिलो राष्ट्रिय संचार,दोस्रो राष्ट्रिय सञ्चार र तेस्रो राष्ट्रिय सञ्चारजस्ता महत्वपूर्ण अभिलेखहरुलाई आधार मानिएको थियो। त्यस्तै यस अध्ययन-अनुसन्धानसँग सम्बन्धित राष्ट्रियस्तरको तथ्याङ्कको अभावका कारण आई.पि. सी.सी. निर्देशिका अनुसार पहिलो तह (Tier 1) अवलम्बन गरिएको छ। साथै उपलब्ध तथ्यांक अनुसार आई.पि. सी.सी. निर्देशिकाको दोस्रो (Tier 2) र तेस्रो तह (Tier 3) पनि प्रयोग गरिएका छन्। यस अध्ययन-अनुसन्धानमा यथार्थ र वस्तुगत जानकारी प्राप्त गर्न प्रदेशका जिल्लाहरु (कास्की,पर्वत,स्याङ्जा,तनहुँ,बागलुङ) मा स्थलगत भ्रमण तथा अवलोकन, मुख्य जानकार व्यक्तिहरूसँग अन्तर्वार्ता पनि गरिएको थियो।

गण्डकी प्रदेशमा कुल कार्बन उत्सर्जन ४२५३.४२ गिगाग्राम कार्बन डाइअक्साइड बराबर (Gg CO2-eq) र कुल कार्बन संचितिकरण २३३०.७९ गिगाग्राम कार्बन डाइअक्साइड बराबर (Gg CO2-eq) रहेको छ। क्षेत्रगत रुपमा कार्बन उत्सर्जन र संचितिकरणको विवरण यसप्रकार रहेको छ।

क्र. सं.	क्षेत्र र उप-क्षेत्रहरू	CO_2-eq (Gg) उत्सर्जन	CO_2-eq (Gg) संचितिकरण
१	ऊर्जा क्षेत्र	२१४२.४२	-
१क.	यातायात उप-क्षेत्र	७०५.६	-
१ख.	आवासीय उपक्षेत्र	१,१८३.७८	-
१ग.	कृषि उपक्षेत्र	३२.८८	-
१घ.	वाणिज्य उप-क्षेत्र	११८.८	-
१ङ.	निर्माण उद्योगहरू	१०१.९	-
२	IPPU क्षेत्र	७७१.१६	
३	AFOLU क्षेत्र	१३३९.८	२३३०.७९
४	फोहोरमैला क्षेत्र	०.०७	-
कुल		४२५३.४५	२३३०.७९

उर्जाक्षेत्रः कुल कार्बनउत्सर्जन मध्ये, उर्जा क्षेत्रले २१४२.४२ गिगाग्राम प्रति वर्ष (५१%) उत्सर्जन गरेको पाईएको छ। यातायत, आवास, कृषि, उत्पादन उद्योग र व्यापारिक क्षेत्रले क्रमशः ७०५.०६ गिगाग्राम , १,१८३.७५ गिगाग्राम, ३२.८८ गिगाग्राम, १०१.९ गिगाग्राम र ११८.८ गिगाग्राम प्रति वर्ष उत्सर्जन गरेको तथ्य पत्ता लगाईएको छ।

औद्योगिक प्रक्रिया र उत्पादन प्रयोग क्षेत्रः औद्योगिक प्रक्रिया र उत्पादन प्रयोग क्षेत्रले कुल ७७१.१६ गिगाग्राम प्रति वर्ष (१८%) उत्सर्जन गरेको पाईएको छ ।

कृषि, वन, र अन्य भूमि प्रयोग क्षेत्रः कृषि, वन र अन्य भूमि प्रयोग क्षेत्रले कुल १,३३९.८ गिगाग्राम प्रति वर्ष (३२%) उत्सर्जन र २३३०.७ गिगाग्राम प्रति वर्ष संचितिकरण गरेको पाईएको छ ।

फोहोर मैला क्षेत्रः यस क्षेत्रको कुल ०.०७ गिगाग्राम प्रति वर्ष (०.००२%) कार्बन उत्सर्जन गरेको पाईएको छ । हालको अवस्थामा कार्बन उत्सर्जन भन्दा कार्बन संचिति कम रहेको छ। तथापि कार्बन संचितिका उपायहरूलाई व्यापक रुपमा अभ्यासमा ल्याउन सकेमा कार्बन संचितिमा वृद्धि हुनुका र गण्डकी प्रदेश कार्बन-न्युट्रल प्रदेशको रुपमा स्थापना हुनेछ।

CHAPTER 1: BACKGROUND

1.1 Overview of Nepal's GHG inventory

Nepal is a small landlocked mountainous country in South Asia bordered by China and India. Despite its relatively small area, Nepal has diverse climatic conditions, ranging from tropical in the south to alpine in the north. The country's three distinct geographies-the snow-covered mountains, the mid hills and the terai (plains)-embody the diversity. Population of Nepal according to census 2021 is 2 91, 92,480 with a 10.18 percent rise in the last 10 years (CBS, 2021). Population growth, along with increasing consumption, tends to increase emissions of climate-changing greenhouse gases.

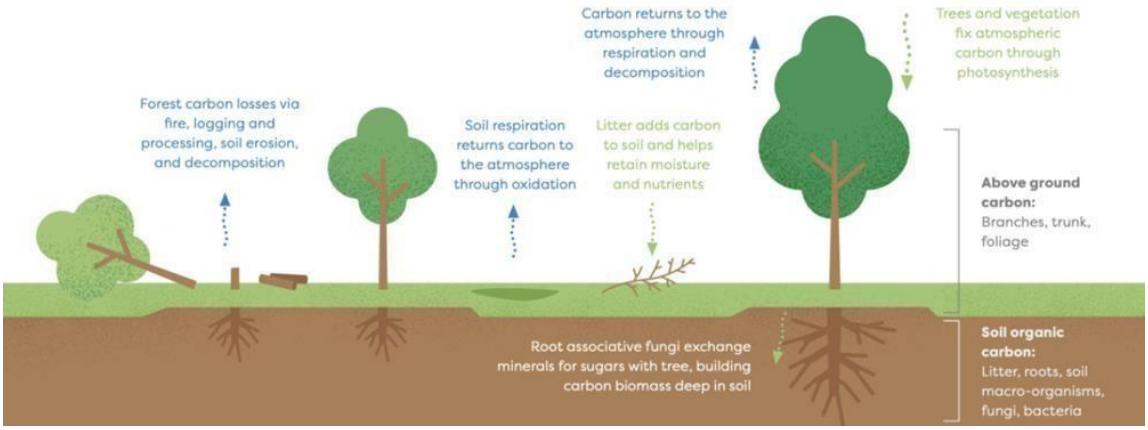
The net GHG emission estimated for Nepal in the base year 2011 was 28,166.06 Gg CO_2-eq which marks a significant increase in emission from the base year 2000/01 i.e. 13,477 Gg CO_2-eq. Similarly, net emissions of CO_2 in the country were estimated at 9747 Gg CO_2-eq for the base year 1994/95. The contribution of Nepal in the global GHGs emission was 0.025% and 0.027% as per the INC and SNC, respectively (MoPE, 2004; MoSTE, 2014).

To overcome the effects of climate change in Nepal, the Government of Nepal has been taking milestone approach since several decades. Nepal became party to the United Nation Framework Convention on Climate Change (UNFCCC) at Rio Earth Summit, held in June 1992. Since then, it has been actively participating in UNFCCC. As a Party, Nepal has commitment to communicate the updates of the national actions on climate change periodically to the Convention. To fulfill the commitment, Nepal has prepared and submitted Initial National Communication (INC) in July 2004, Second National Communication (SNC) in December 2014 and Third National Communication (TNC) in June 2021. One of the components of the National Communication document is an incorporation of greenhouse gas (GHG) inventories.

1.2 Carbon sequestration and carbon emission

The term "carbon sequestration" is used to describe both natural and deliberate processes by which CO_2 is either removed from the atmosphere or diverted from emission sources and stored in the ocean, terrestrial environments (vegetation, soils, and sediments), and geologic formations. Before human-caused CO_2 emissions began, the natural processes that make up the global "carbon cycle" maintained a near balance between the absorption (sequestration) of CO_2 and release back to the atmosphere (emission). At present, existing CO_2 uptake mechanisms (sometimes called CO_2 or carbon "sinks") are insufficient to offset the accelerating pace of emissions related to human activities. In recent years, carbon sequestration and reduced emissions from deforestation have

received more attention as methods to help reduce the buildup of greenhouse gases in the atmosphere. Biological growth involves the process of a plant utilizing CO_2 from the atmosphere: Plant draws the carbon into its cells and releases oxygen (O_2) back into the atmosphere. Destruction of biological matter essentially reverses this process: Carbon is released back into the atmosphere, where carbon combines with two O_2 atoms to form CO_2. Forests and soils sequester atmospheric CO_2 within their biomass or in organic matter that is stored in the ground. Oceans store most of the world's carbon, but forests and soils store most of the carbon sequestered within land. Worldwide, forests store approximately 47% of total global carbon (Malhi et al. 2002).

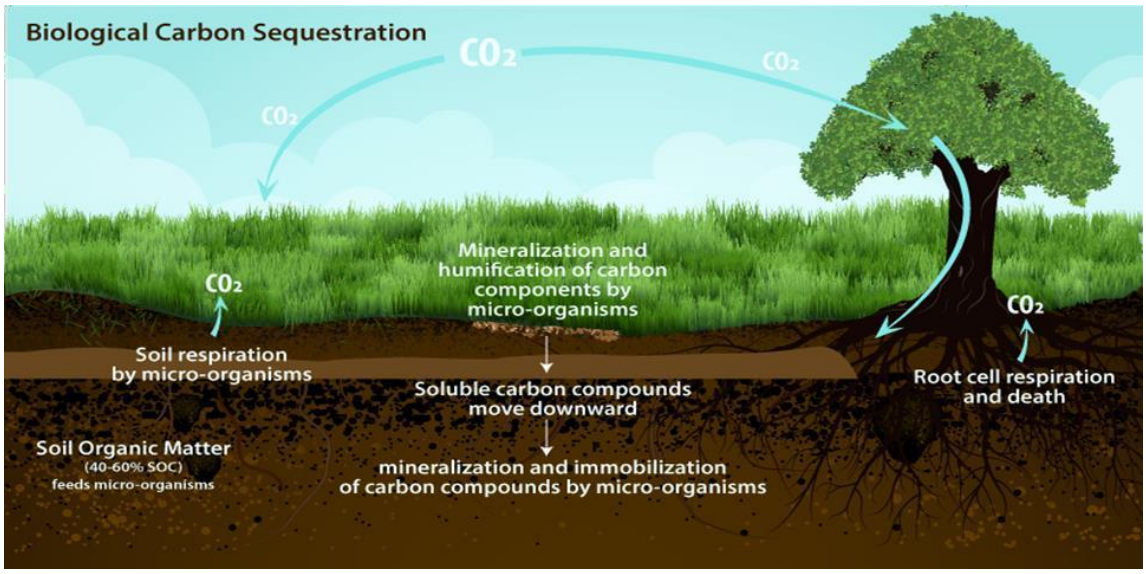


Source: Minnesota Board of Water and Soil Resources

Figure 1: A pictorial diagram of process of Forest Carbon Sequestration

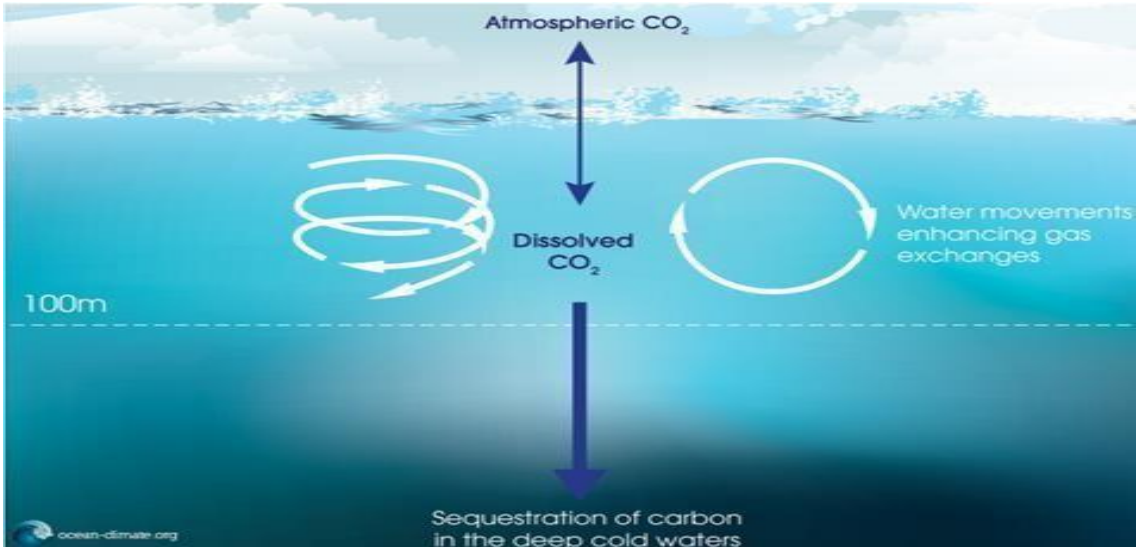
Although forests are able to sequester a lot of carbon, they also release some CO_2 back into the atmosphere when debris or a dead tree (or any other type of vegetation) begins to decompose. In addition to natural decomposition, the other sources of CO_2 emission are tree harvesting and fires.

In addition to forests and forest soils, agriculture soil is also a major carbon sink. Carbon is sequestered within soil in two ways, both involving photosynthesis. The first is through humification and second one is through micro-photosynthesis. The carbon sequestered in soil can stay in the ground for a long period of time. Carbon is released when microbes come in contact with humus and decompose it for energy. How quickly microbes come in contact with undiscovered pockets of humus depends largely on various conditions, including soil drainage, climate, natural vegetation, and soil texture (Sedjo & Sohngen, 2012).



Source: chloridefree.org

Figure 2: A pictorial diagram of process of Soil Carbon Sequestration



Source: Ocean-climate org

Figure 3: A pictorial diagram of process of aquatic carbon sequestration

Greenhouse gases present in the atmosphere absorb infrared radiation, trapping heat in the atmosphere. Water vapor contributes 36-70% of the total greenhouse effect on earth (not including clouds); carbon dioxide contributes 9-26%, methane contributes 4-9%, and ozone contributes 3-7% (IPCC, 2001). Carbon dioxide is the most significant greenhouse gas, responsible for about three-quarters of emissions. Carbon dioxide is associated with global warming. Anthropogenic carbon dioxide emissions result primarily from burning fuel for energy, industrial processes, farm activities and deforestation. But, carbon dioxide emissions from industry, transportation and agriculture are very likely to be the main causes of recently observed global warming (Karki, 2007). In combustion

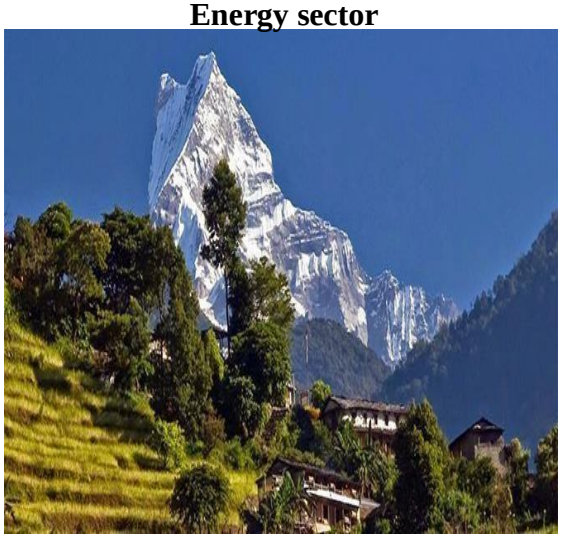
different fossil fuels release different amounts of carbon dioxide for the same level of energy use: oil releases about 50 percent more carbon dioxide than natural gas, and coal releases about twice as much. Cement manufacturing releases about half a metric ton of carbon dioxide for each metric ton of cement produced. Since pre-industrial times, the measured concentrations of some anthropogenic carbon dioxide emission in the atmosphere has been rising. There are many ways to reduce carbon dioxide emissions, including energy efficiency, fuel switching, combined heat and power, use of renewable energy, and the more efficient use and recycling of materials.

(Source:Thenepalipost.com)

Energy sector

(Source:Kathmandupost.com)

IPPU sector



(Source:Moitfe.gandaki.gov.np)

AFOLU Sector

(Source: Nepallivetoday.com)

Waste sector

Figure 4: Potential sources of carbon from the four sectors

Carbon is emitted from various sources but here, we only present the four importance sectors/source; a) Energy sector, b) Industrial Processes and Product Use Sector (IPPU), c) Agriculture, Forestry and other Land use sector (AFOLU), and d) Waste sector.

1.3 Study area

This study was conducted to determine Carbon sequestration and carbon emission in Gandaki Province. Gandaki Province is one of the seven federal provinces with an area 21,504 km^2 - about 14.57% of the country's total area and population 2,479,745 according to the latest census, 2021. The country extends between 27°-20' N ~ 29°-20' N latitude and 82° 52' E ~ 85°-12' E longitude. In terms of terrain, the province is spread over the Himalayan, Hilly and Terai region of Nepal; 5,919 km^2 (26.8%) of the area falls under the Himalayan region, 14,604 km^2 (67.2%) of the area falls under the Hilly region and 1,310 km^2 (6%) of the area falls under the Terai region. Gandaki province is divided into 11 districts, which are further divided into one metropolitan city, 26 municipalities and 58 rural municipalities. It borders the Tibet Autonomous Region of China to the north, Bagmati Province to the east, Karnali Province to the west, and Lumbini Province and Bihar of India to the south.

Gandaki Province has diverse climatic zones; less than 1500 meters (Sub-tropical climate), 500 – 3000 meter (Temperate climate), 3000-45000 meters (Alpine climate). Gandaki Province experiences an average rainfall of between 2500-250 mm. Mustang, the High Himalayan district receives the lowest annual rainfall of 146mm only while Lumle, situated in Parbat district is the wet area having record rainfall of 5284mm.

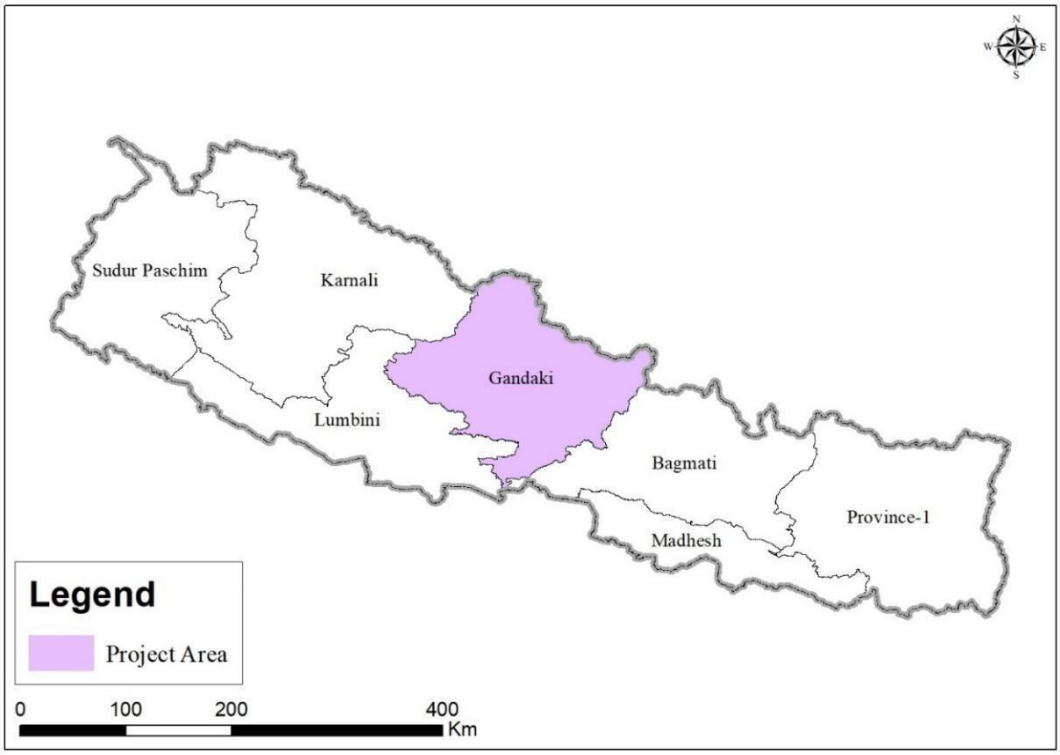


Figure 5: Gandaki Province shown on a Map

The population density is about 110 persons per square kilometer with population growth rate of -0.33%. The sex ratio is 89 males for 100 females, with a total of 948,028 males and 1,144,124 females recorded in 2011. Hill Brahmins are the largest community with 21.26% of the population. Other aboriginal Khas communities include Khas/Chhetri (13.13%), Kami (8.66%), Sarki (4.10%), Damai (3.84%), Thakuri (1.61%) and Kumal (1.49%). The janajati groups are Magar (18.79%), Gurung (11.30%), Newar (4.23%), Tamang (2.03%), Tharu (1.68%) and Bhujel (1.27%) (Annual Progress Report, 2077, www.moitfe.gandaki.gov.np).

1.4 Objectives of the study

The main objective of this study is to assess carbon emission and sequestration in Gandaki Province. The specific objectives of the study are as follows:

- To determine the total carbon emission of Gandaki Province,
- To determine the total carbon sequestration of Gandaki Province.

1.5 Limitations of the study

- Base year for the four sectors has been treated on the basis of the availability of the latest data
- Almost all the data used while preparing this report have been collected from the secondary sources (priority has been given to the government sources).
- The contribution of Harvested Wood Product (HWP) in carbon storage was not considered.

1.6 Methodology

This research adopted both primary and secondary data collection methods. Firstly, approaches were made to collect the primary data through the key informants interview. A total of 54 key informants were interviewed in Baglung, Kaski, Parbat, Kushma, Parbat and Syangja to collect factual information from a wide range of related authority (Annex: 2). In addition to this, field visits were made in different governmental departments of Gandaki Province and Central government institutions.

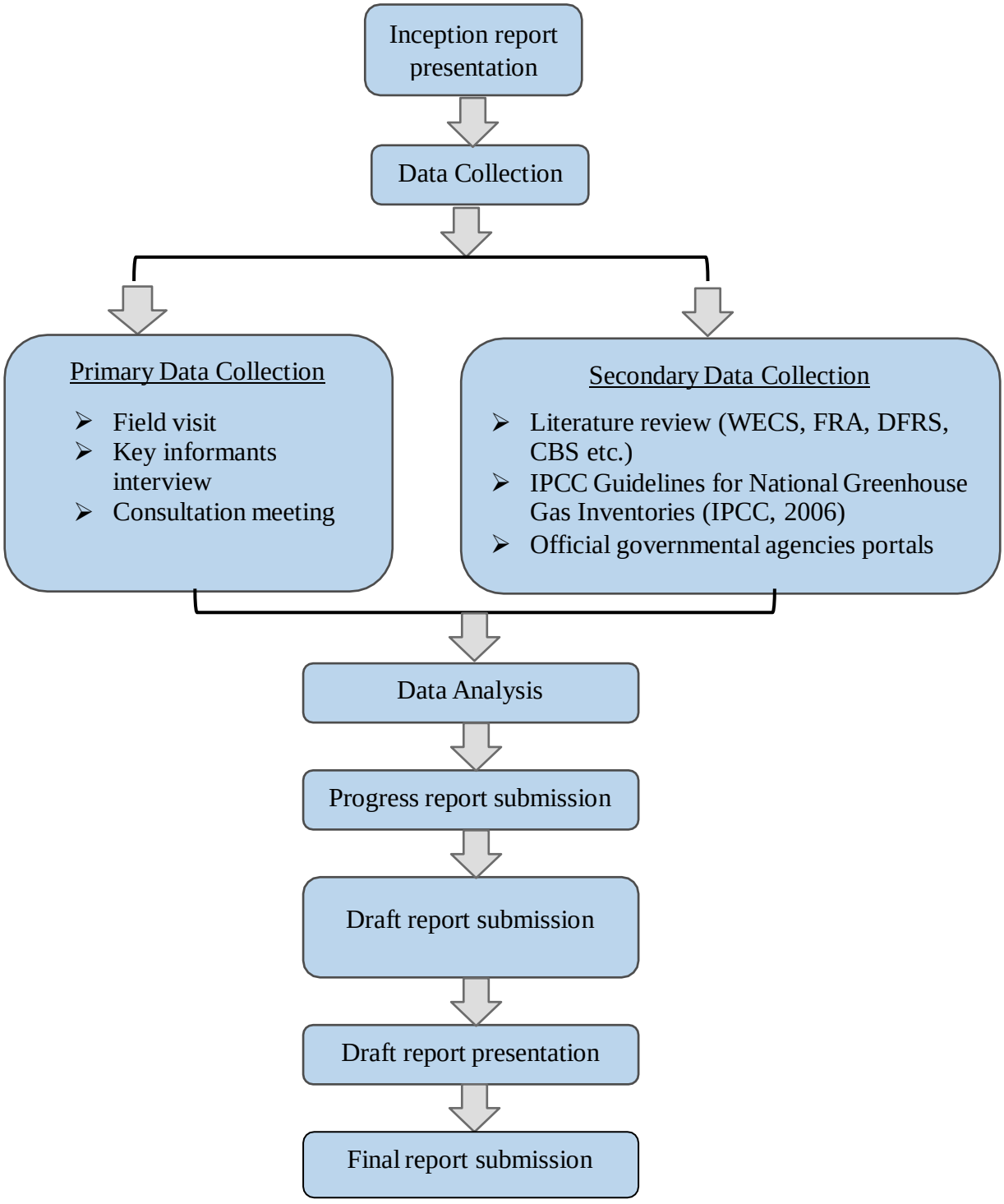
For secondary data collection, the team reviewed various national and international publications (available online or in print form). Published by the country, the documents like Nepal's GHG Inventory of Initial National Communication Report, Second National Communication Report and Third National Communication were treated as the guiding document and reviewed excessively to get an overview and to plan for this study. In addition, IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) was also reviewed for the estimation of emissions of the carbon from four sectors (Energy; Industrial Processes and Product Use; Agriculture, Forestry and Other Land Use; Waste). The activity data and emission factors for the carbon inventory of Gandaki province

were collected from various data sources (mentioned in the sector-wise analysis) and the data were categorized according to IPCC 2006 Guidelines. The relevant secondary data on carbon emission from various sectors (Energy, Industrial Processes and Product Use, Agriculture, Forestry, and Other Land Use, and Waste) were collected from numerous documents/sources including: -

- Energy Sector Synopsis Report 2010 and 2014. Water and Energy Commission Secretariat, Kathmandu, Nepal.
- High Mountains and High Himal Forests of Nepal, 2015. Forest Resource Assessment (FRA) Nepal, Department of Forest Research and Survey (DFRS, 2015). Kathmandu, Nepal
- Middle Mountains Forests of Nepal, 2015. Forest Resource Assessment (FRA) Nepal, Department of Forest Research and Survey (DFRS). Kathmandu, Nepal.
- 2015 Statistical year book Nepal. Kathmandu: Central Bureau of Statistics, published by CBS (in 2016).
- Waste management baseline survey of Nepal 2020, published by Central Bureau of Statistics, February 2021
- Nepal: Sustainable Solid Waste Management in Mountain Areas, January, 2021
- Portals of the official governmental agencies (Department of transport management, Nepal oil corporation, Water and Energy Commission Secretariat (WECS), Department of Industry, Trade and Export Promotion Center(TEPC), Ministry of Industry, Commerce and Supplies, Trade and Export Promotion Centre and not limited).

Inception report presentation was done on 2nd Magh, 2078 with detailed methodology and work plan. The participants provided genuine feedback and comments on various aspects of the study and were incorporated in the process of research and data collection. Then, field visits were conducted in the districts (mentioned above) and the basis of primary and secondary data, the team analysed the data and draft report was prepared which was submitted to FRTC. This draft report was presented in Ministry of Forest, Environment and Soil conservation on 13th Jestha, 2079 in the presence of respected Secretary of Ministry of Forest, Environment and Soil Conservation, Gandaki Province along with the keen participation by the Provincial level stakeholders. The comments, suggestions, feedbacks were incorporated in final report and submitted to FRTC. Methodological framework below illustrates the major steps followed during this research.

Methodological framework:



CHAPTER 2: ENERGY

2.1 Overview of the sector

The energy sector is usually the most important sector in greenhouse gas emission inventories, and typically contributes over 90 percent of the CO_2 emissions. In 2010, the energy supply sector was responsible for approximately 35% of total anthropogenic GHG emissions. Despite the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, CO_2 emissions grew more rapidly between 2000 and 2010 than in the previous decade. The energy sector includes all fuel combustion-related emissions from transport, residential, commercial, industrial and agricultural sub-sector. The CO_2 emissions from energy sector comprises estimates of emissions due to combustion of fuels in stationary and mobile sources. The stationary sources include fuel combustion in residential, commercial, manufacturing industries and agricultural activities. Mobile sources include road transport and civil aviation.

The activity data and emission factors for the greenhouse gas inventory of Nepal were collected from various data sources and the data were categorized according to 2006 IPCC. Tier 1 method which applies IPCC default emission factors and uses IPCC default models was considered. Tier 1 approach was adopted (use of the default models and emission factors as provide by IPCC) for the calculation of carbon emission for this sector.

2.2 Data and Methods

2.2.1 Data

The main basis of this inventory comprises data from numerous sources, including Central Bureau of Statistics (CBS), Ministry of Physical Infrastructure, Urban Development and Transport Management, Gandaki Province (MOPID), Department of Transport Management, Gandaki Province (DOTM), Water and Energy Commission Secretariat (WECS), Nepal Oil Corporation Ltd. Gandaki Provincial Office (NOC). Additional and/or missing data, required to meet the level of disaggregation was sourced from Second National Communication (SNC) and Third National Communication (TNC) that are GON's authentic reports. The data (consumed in Gandaki Province) related to aviation turbine fuel was received from NOC. Publications related to energy sectors were also reviewed. The data source is summarized in the Table 1.

Table 1: Activity data and data Source.

Category	Data need	Data source
Transportation	Civil Aviation	NOC
	Road Transport	DOTM, WECS, MOPID
Other Sectors	Commercial	Ministry of Energy, GIZ and WECS
	Agricultural	WECS
	Residential	WECS
	Manufacturing Industries	WECS

2.2.2 Methodology

For the inventory of carbon emission from this sector, we adopted the following documents: IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), Initial National Communication (INC), Second National Communication (SNC) and Third National Communication (TNC).

The 2006 IPCC Guidelines provide a number of possible methodologies for calculating emissions or removals from a given category. The methodologies are given in the forms of 'tier' which includes various levels of detail at which estimates can be made. The choice of method depends on factors such as the importance of the source category and availability of data. The methods for estimating emissions and/or removals are distinguished between the tiers as follows:

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

This inventory was based on approaches as determined by Top Down Approach (Reference Approach) and Bottom Up Approach (Sectorial Approach) using the IPCC Tier 1 and Tier 2 framework. Selection of emission factors (EFs) significantly affects the estimates of emission. For this inventory, the most suitable EFs have been selected from the IPCC database for the year. The table in ANNEX-3 shows EFs used in the projection of energy-sector CO_2 emission. Accordingly, applying a Tier 1 emission estimate requires the following for each source category and fuel.

- Data on the amount of fuel combusted in the source category.
- A default emission factor

Carbon emissions from stationary combustion

$$\text{Carbon emission} = \sum \text{fuel consumption for each sector} \times \text{carbon emission factor}$$

Where,

Carbon emissions = emissions of a given GHG by type of fuel (kg GHG)

Fuel Consumption = amount of fuel combusted (TJ)

Emission Factor = default emission factor of a given GHG by type of fuel (kg gas/TJ). For CO_2, the carbon oxidation factor is assumed to be 1.

Carbon emissions from mobile combustion

$$\text{Carbon emission} = \sum (Fuel_a * EF_a)$$

Where,

Carbon Emission = Emissions of CO_2 (kg)

$Fuel_a$ = fuel sold (TJ)

EF_a = emission factor (kg/TJ). This is equal to the carbon content of the fuel multiplied by 44/12.

a = type of fuel (e.g. petrol, diesel, natural gas, LPG etc)

Top-Down Approach

This approach uses the data of provincial energy supply to estimate the emissions of CO_2 from combustion of ATP. For this, data from Nepal Oil Corporation (NOC), Gandaki Provincial Office which is the sole entity responsible for the import and distribution of ATP is used. The Central Bureau of Statistics (CBS, 2011) provided the data of total household and energy consumed while using different fuel type in cooking by Gandaki province households.

Bottom-Up Approach

In the bottom-up approach, all of the selected data sources identified were the major energy-consuming sectors. There is no comprehensive database available in Provincial level that could provide the fuel consumption by all the sources in various sectors. Fuel consumption by each sector were identified along with the fuel types. Relevant sectors were identified according to the IPCC 2006 Guidelines; however, the sectors were not strictly adhered to as the sectors mentioned in the

guidelines might not be relevant in the context of Nepal. The consumption of fuel was estimated from the energy statistics provided by CBS and from the energy sector synopsis report 2014 by WECS.

2.3 Carbon Emission from Energy Sector

Energy Sector contributes 2142.42Gg of CO_2 emission (CO_2-eq) in Gandaki Province. The various contributors to the CO_2 emissions within energy sector are summarized in Table 2. Residential sector (1,183.78 Gg) is the largest contributor to CO_2 emission while Agricultural sector (32.88 Gg) contributed the least (See Table 2, Figure 6).

Table 2: Summary of CO_2 emissions from Energy Sector

S.N.	Categories	CO_2- eq (Gg)
1	Transportation Sector	705.06
2	Residential Sector	1,183.78
3	Agricultural Sector	32.88
4	Commercial Sector	118.8
5.	Manufacturing Industries	101.9
	Grand Total	**2142.42**

Source: LENS, 2022

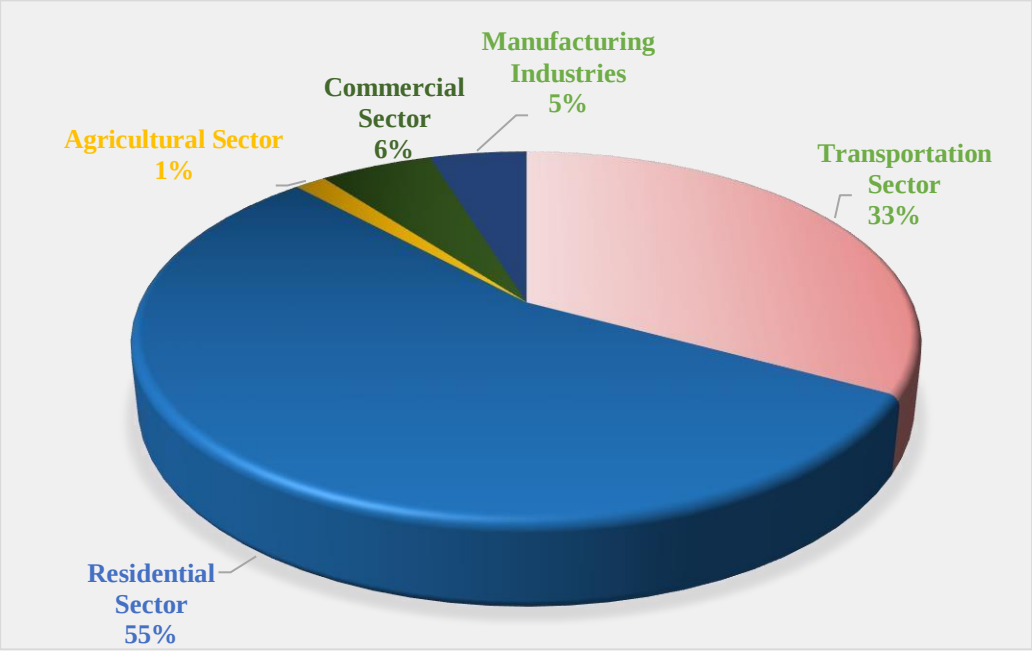


Figure 6: CO_2 (in Gg) by various energy sectors in Gandaki province

2.3.1 Carbon emission from transportation sector

Road transportation is predominant mode of transport and accounts for 90% of the movement of passengers and goods. Diesel is the main fuel type used for mobility followed by petrol. The total amount of carbon emitted is 403.76 CO_2-eq. which is nearly three times less than the amount of CO_2 mentioned in TNC report. However, TNC report is based on 2010/2011 data so by 2021, we assume that amount of emission must have doubled if not trebled. Figure 7 shows that Bus/minibus/truck/minitruck is the largest emitter with about 403.6 Gg of CO_2 and three-wheeler (2 Gg of CO_2) emitted the lowest.

The data on the total vehicle population was obtained from the Ministry of Physical Infrastructure, Urban Development and Transport Management, Gandaki Province (MOPID) and Department of Transport Management, Gandaki Province (DOTM). The activity data was estimated by using the distance traveled and fuel efficiency approach which was used in Second National Communication (SNC) report. The emission factors used in this report are default emission factors available in IPCC publications (1997, 2000, 2003 and 2006).

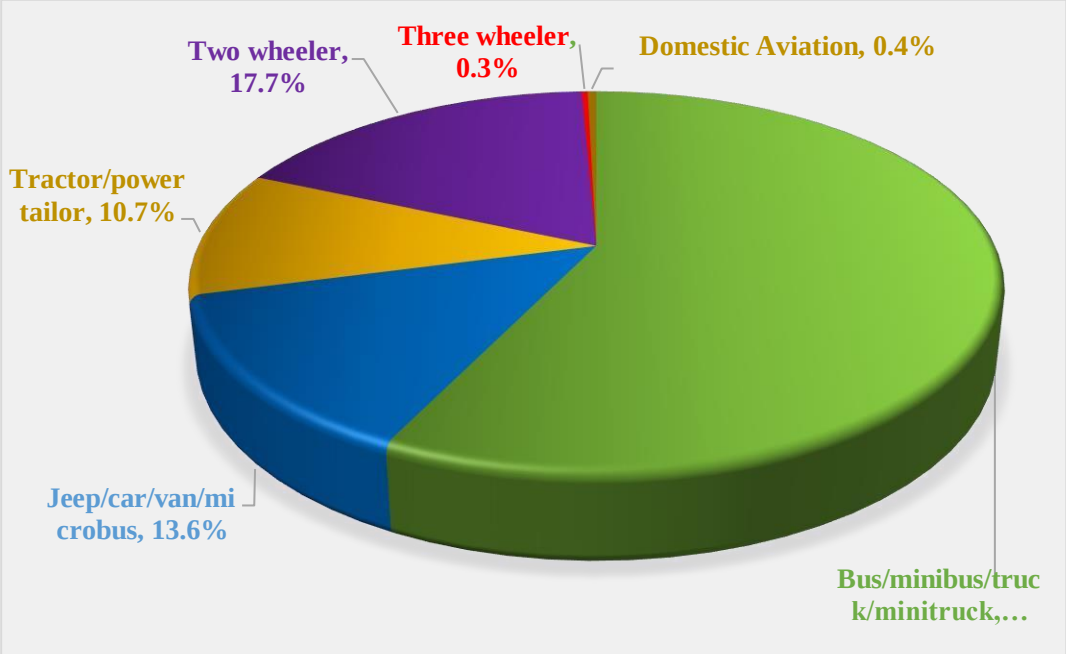


Figure 7: CO_2 emission by subsectors under transportation sector

2.3.2 Carbon emission from residential sector

Nepalese Residential Subsector depends primarily on biomass for its primary energy need, basically for cooking. However due to rapid urbanization, there has been shift from traditional energy dependence towards fossil fuel, i.e., LPG (and kerosene). The residential sector accounts almost 58% (1,183.78 Gg of CO_2) of the total carbon emission in Gandaki Province. The energy consumption

used in this sector is for cooking and is obtained from the data given by Central Bureau of Statistics (CBS,2011) and the emission factors used in this residential sector are default emission factors available in IPCC publications (1997, 2000, 2003 and 2006) and Ramachandra and Shwetmala (2009). From the figure 8, it is seen that firewood is still the dominant fuel used by rural households which share highest emission of CO_2 i.e., 1173.85 Gg of CO_2 than others. According to (MOF, 2020b), fuelwood consumption has increased from 7.3 Mtoe in 2008/9 to 8.7 Mtoe in 2017/18, an increase of 19%. Also, Sharma, 2019, findings revealed that there were overall 84 percent share of firewood in household cooking.

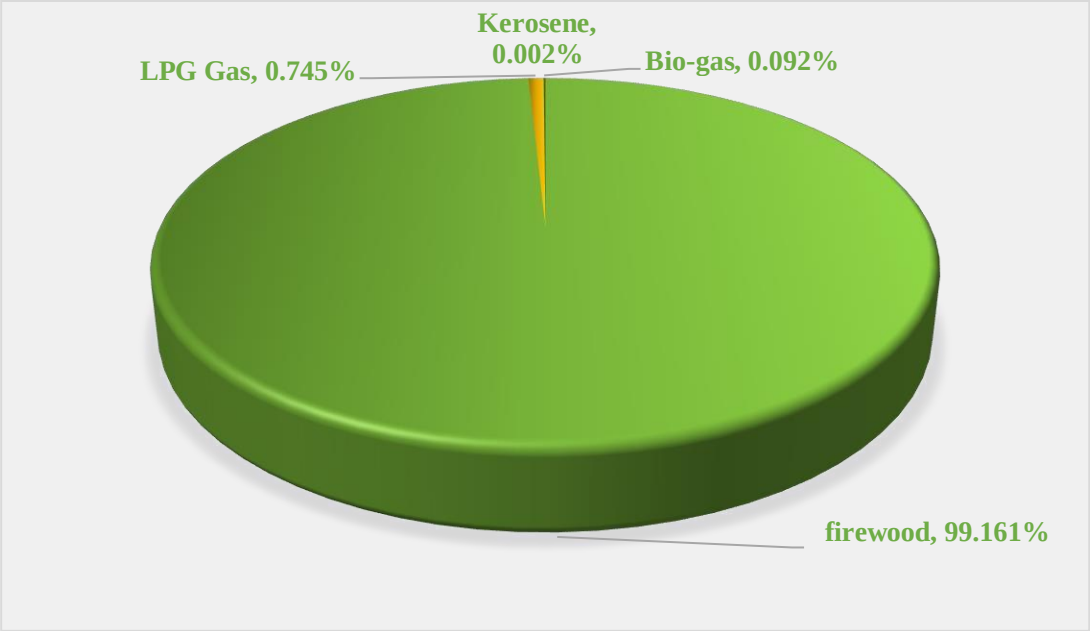


Figure 8: CO_2 emission by different fuel types in residential sector

2.3.3 Carbon emission from agricultural sector

Most of the agriculture activities in Gandaki Province are carried out traditionally, however in recent years, mechanization is increasing especially for irrigation, tillage and threshing activities. Diesel is the major fuel type used in this sector so this sector emitted 32.88 Gg covering 98.48% of the fuel used in this sector. The total energy consumed in the agriculture sector has been calculated on the basis of report by WECS, June 2014 and the emission factors used in this agricultural sector are default emission factors available in IPCC publications (1997, 2000, 2003 and 2006).

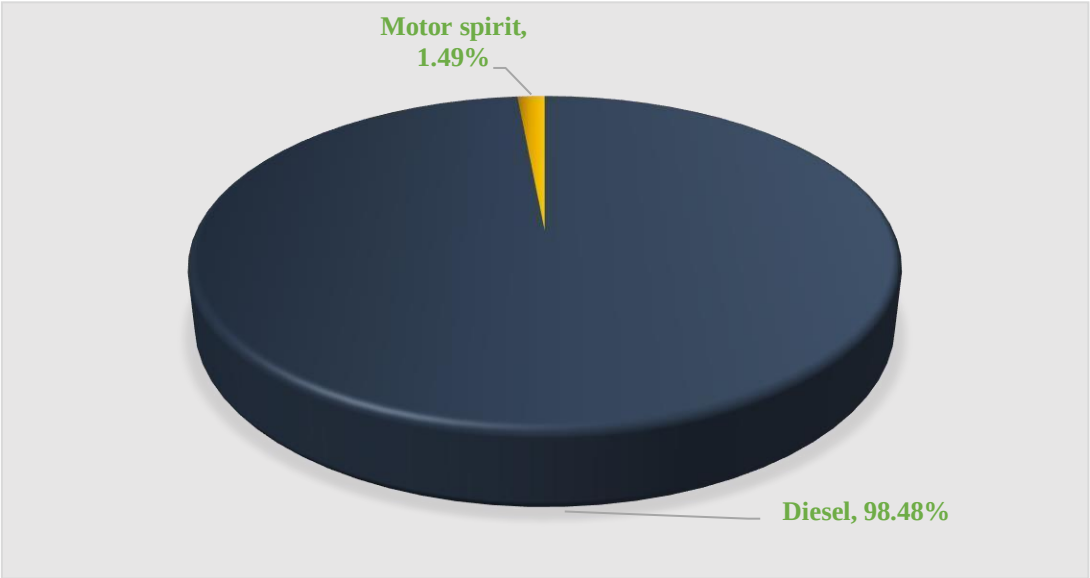


Figure 9: CO_2 emission by different fuel types in agricultural sector

2.3.4 Carbon emission from commercial sector

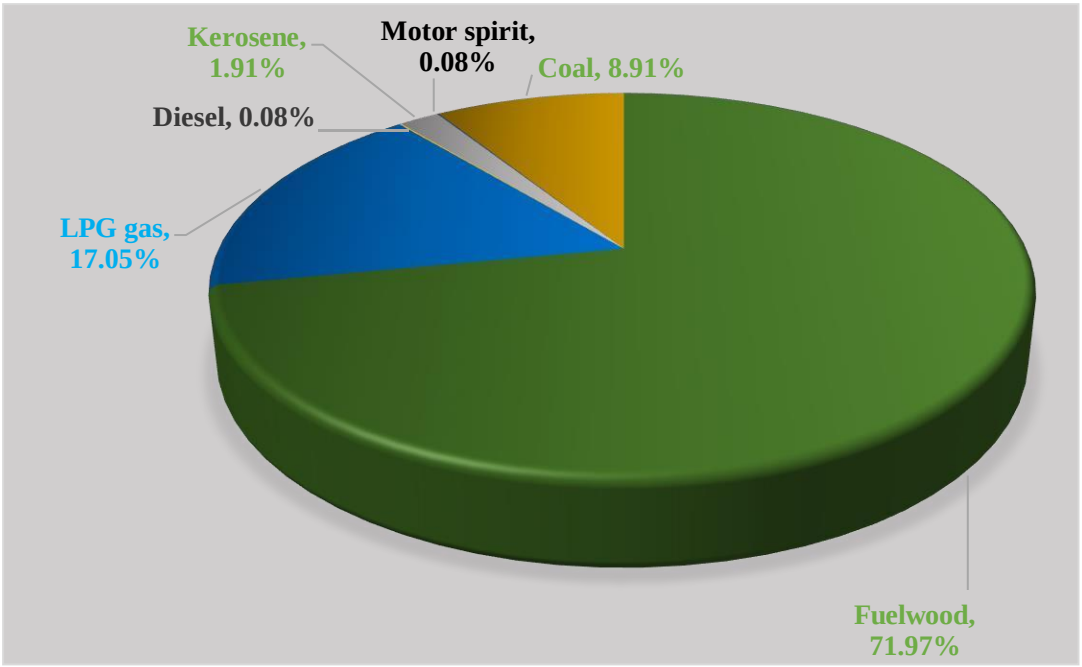


Figure 10: CO_2 emission by different fuel types in commercial sector

In the commercial sector, key activities include lighting, cooking, space heating/cooling, pumping, running of equipment's and appliances. Sources of energy for this sector are grid-based electricity, LPG, kerosene, diesel, motor spirit, coal and fuel wood. The sub sectors of commercial sector included are academic institutions, barrack/canteen, financial, health service, hotel and restaurant, institutional and service sector. This sector emitted 118.8 Gg of CO_2. Fuel wood is the major fuel used in this subsector i.e. 71.97% which emitted 85.5 Gg of CO_2 (Figure 10). The total energy consumed in the commercial sector has been calculated on the basis of report by WECS, June 2014

and the emission factors used are default emission factors available in IPCC publications (1997, 2000, 2003 and 2006).

2.3.5 Carbon emission from manufacturing industries

Industrial sector in Gandaki Province comprises of agro-based, construction based, manufacturing, mineral base and power based industries. They used both the thermal and electrical energy. Fuelwood, coal and diesel contribute 55.6%, 15.6% and 27% respectively of total energy used in the industrial sector (Figure 11). This sector emitted 101.9 Gg of CO_2. The total energy consumed by the manufacturing industries has been calculated on the basis of report by WECS, June 2014 and the emission factors used are default emission factors available in IPCC publications (1997, 2000, 2003 and 2006).

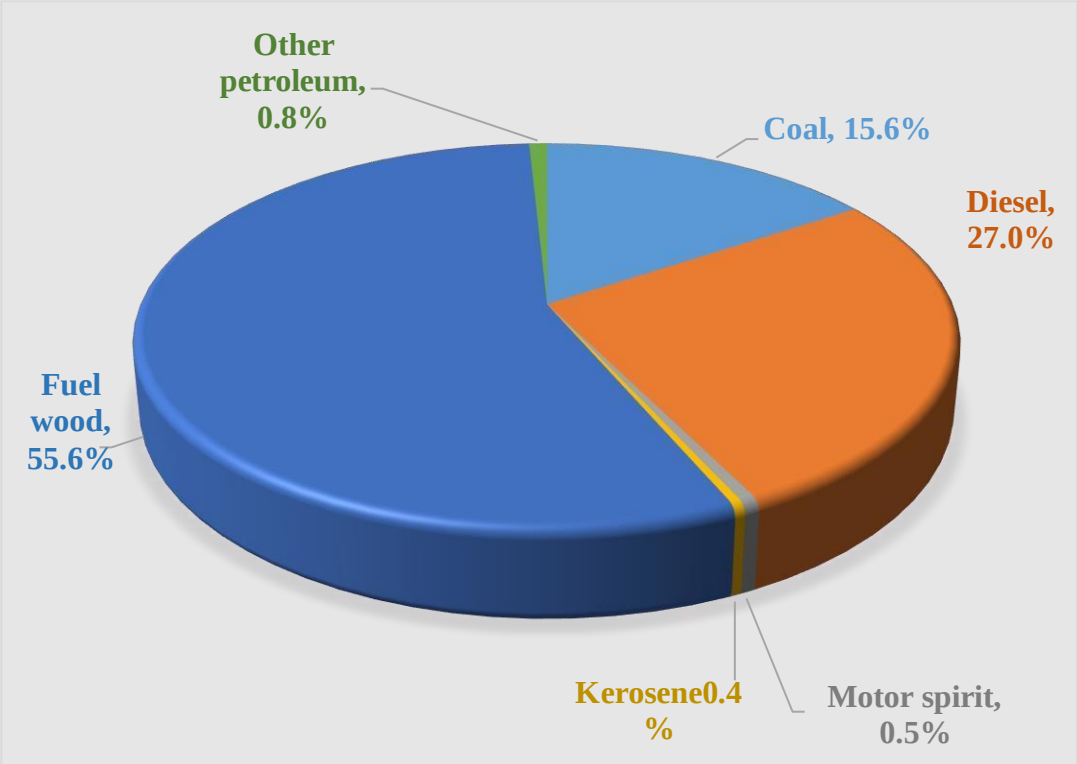


Figure 11: CO_2 emission by different fuel types in manufacturing industries

Among the five sub-sectors, residential sector releases more CO_2- eq to the atmosphere while agriculture sector releases the least (Table 3).

Table 3: CO_2 emission inventory of Energy Sector

S.N.	Categories	Energy Consumed (TJ)	CO_2- eq (Gg)
1	**Transportation Sector**	**9644.26**	**705.06**
1a	Bus/minibus/truck/minitruck	5446.8	403.6
1b	Jeep/car/van/microbus	1298.3	96.2
1c	Tractor/power tailor	1016.6	75.3
1d	Two-wheeler	1804.3	125.0
1e	Three-wheeler	28.5	2
1f	Domestic aviation	49.8	2.91
2	**Residential Sector**	**10644.6**	**1183.78**
2a	Firewood	10480.8	1173.85
2b	Kerosene	0.3	0.02
2c	LPG gas	139.8	8.82
2d	Bio-gas	20.0	1.09
3	**Agricultural Sector**	**443.71**	**32.88**
3a	Diesel	437.04	32.38
3b	Motor spirit	6.67	0.49
4	**Commercial Sector**	**1232.93**	**118.8**
4a	Fuelwood	763.4	85.5
4b	LPG gas	321.0	20.26
4c	Diesel	1.3	0.096
4d	Kerosene	31.7	2.27
4e	Motor spirit	1.2	0.092
4f	Coal	114.3	10.59
5	**Manufacturing Industries**	**1073.9**	**101.9**
5a	Coal	171.9	15.9
5b	Diesel	371.8	27.6
5c	Motor Spirit	7.4	0.5
5d	Kerosene	5.2	0.4
5e	Fuelwood	506.1	56.7
5f	Other Petroleum	11.4	0.8

Source: LENS, 2022

CHAPTER 3: INDUSTRIAL PROCESSES AND PRODUCT USE

3.1 Overview of the sector

Industries are one of the key sources of Carbon however in Gandaki Province, there are very few industries and most of them like pulp and paper industry, food and beverages industry, iron and steel production, lubricant use and paraffin wax use release GHGs. Since we only considered CO_2 in this study, we have only calculated the CO_2 emission from Cement Industry (the highest contributor of CO_2). There were 70 cement industries in 2020/21 A.D., throughout Nepal as per DOI, out of which only two are located in Gandaki Province. In cement industry CO_2 emission is mainly observed in clinker production from the reaction (**Limestone $CaCO_3$ + heat → CaO + CO_2)**

Gandaki Province does not have lime production industry and data is limited. Since, the contribution of the cement production is the most significant in carbon emission, it has been considered as the major category in the IPPU sector and hence, only cement production industry is considered in this report. The activity data and emission factors for carbon were collected from various data sources and the data were categorized according to 2006 IPCC guideline.

3.2 Data and Methods

3.2.1 Data

Activity data for estimating the CO_2 emissions from industrial processes and products are sourced from the Department of Industry (DoI) and Trade and Export Promotion Centre (TEPC).

3.2.2 Methodology

The IPCC (2006) guideline has been used to estimate the carbon emissions for the IPPU sector. Since only cement production has been selected in the IPPU sector, tier 1 method has been employed. In the Tier 1 method, emissions are based on clinker production estimates inferred from cement production data, correcting for imports and exports of clinker. In the absence of data on carbonate inputs or provincial clinker production data, cement production data was used to estimate clinker production by taking into account the amounts and types of cement produced and their clinker contents and including a correction for clinker imports and exports. As both (Hongshi Shivam Cement Industry Pvt. Ltd. and C.G. Cement Industry Private Ltd.) the cement industry produced their own clinkers there is no need of clinker imported data. Similarly, emission from the export of the clinkers were not considered due to the lack of data availability and the total cement production was assumed as their total installed capacity acquired form Department of Industry (DOI). An emission factor for clinker is applied and then, the CO_2 emissions are calculated according to given formula:

$$CO_2 \text{ Emission} = [\sum_i (Mci * Ccli) - Im + Ex] * EFclc$$

Where,

CO_2 Emissions = emissions of CO_2 from cement production, tonnes

Mci = weight (mass) of cement produced of type i, tonnes

Ccli = clinker fraction of cement of type i, fraction

Im = imports for consumption of clinker, tonnes

Ex = exports of clinker, tonnes

EFclc = emission factor for clinker in the particular cement, tonnes CO_2/tonne clinker. The default clinker emission factor (EFclc) is corrected for cement kiln dust CKD).

Emission Factor

Emission factors have been obtained from the IPCC emission database and European Monitoring and Evaluation Program/European Environment Agency emission (EMEP-EEA) database. These sources of emission factors are used throughout the estimation since national emission factors are generally not available for Nepal. For, tier 1 Method Good practice guideline given by IPCC (2006): use a default CaO content for clinker of 65 percent

EFclc = 0.51 * 1.02 (CKD correction) =0.52 tonnes CO_2/tonne clinker

EFclc: emission factor for clinker in the particular cement, tonnes CO_2 /tonne clinker

CKD: Cement kiln dust

3.3 Carbon emission from IPPU sector

The share of IPPU Sector for CO2 emission was 771.06Gg of CO_2 emission (CO_2-eq) in Gandaki province. Hongshi Shivam Cement Pvt. Ltd. is the largest contributor of CO_2 emission with 740.22 Gg followed by C.G. Cement Industry Pvt. Ltd i.e., 30.84 Gg (Table 4).

Table 4: IPPU Sector CO_2 emission inventory for base year 2020

S.N.	Name of Industry	Installed capacity (TDP)	Clinker Fraction	Emission Factor (EFclc)	Carbon emission (tons/year)	Carbon emission (Gg/year)
1	C.G. cement Industry Pvt. Ltd	250	0.65	0.52	30842.5	30.84
2	Hongshi Shivam cement Pvt. Ltd	6000	0.65	0.52	740220	740.22
	Total					**771.16Gg/yr**

Source: LENS, 2022

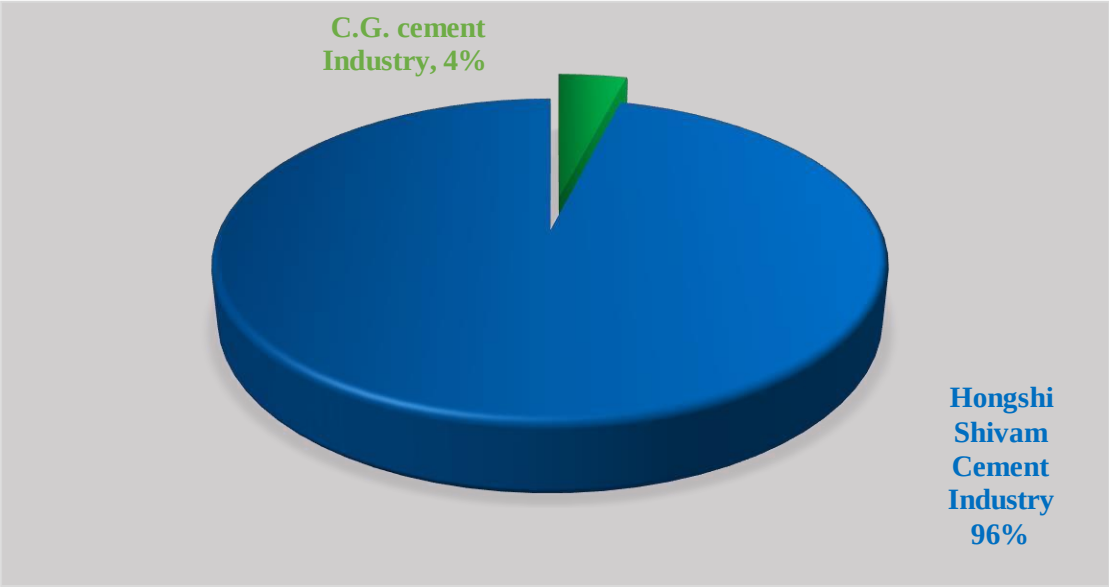


Figure 12: CO_2 emission by cement industries in IPPU Sector

CHAPTER 4: AGRICULTURE, FORESTRY AND OTHER LAND USE

4.1 Overview of the sector

This section presents carbon emissions by source and sequestration in agriculture, forestry, and other land use (AFOLU) activities. In contrast to other sectors, the AFOLU incorporates both emissions by sources of CO_2 and sequestration from forest/vegetated land. For example, emission is resulted from deforestation and forest fire and sequestration from forests and afforestation-related activities (conversion of denuded areas into forests and stable forest area).

According to the few reports, agricultural residues are burnt in the field but such data are not available at the Provincial level. Emission factors such as carbon fraction and nitrogen fraction from burning agricultural residues are also not available in Nepal. Moreover, there are limited practices of field burning of agricultural residues; so, emission from this activity is negligible. Moreover, as the biomass burned is generally replaced by re-growth over the subsequent year, the CO_2 released is not considered to be the net emission. An equivalent amount of carbon is removed from the atmosphere during this re-growth to offset the total carbon released from combustion. Therefore, the long-term net emission of CO_2 is considered to be zero (IPCC 1997). Agricultural soil management system emits direct Nitrous oxide from agriculture fields, excluding cultivation of histosols whereas indirectly from atmospheric decomposition of Ammonia (NH_3) and NOx as well as leaching. As this study is concerned only on the CO_2 emission. Hence, emission from agriculture is not included in the estimation.

For this sector, this study adopted Tier 2 and Tier 3 methodologies for inventory analysis. This report used data of 2019 provided by Forest Research Training Center (FRTC), published in National Land Cover Monitoring System in 2022. The result of National Land Cover Monitoring System 2022 was compared with Land cover data published by Department of Forest Research and Survey (2015) to find out the land cover change matrix. Data on forest fire was taken from MODIS.

4.2 Data and Methods

4.2.1 Data

The main sources of data used in this analysis were database, documents and information portals of the official governmental agencies and data provided by FRTC and data from MODIS.

4.2.2 Methodology

CO_2 emissions and sequestration by sources in the AFOLU sector were computed from the official national activity data using the 2006 IPCC standard guideline. Stratification was done based on forest cover i.e.

a. Forest Loss (FL): Forest converting to non-Forest

b. Forest Gain (FG): Non-Forest converting to forest

c. Stable Forest: Forest Remaining as Forest

d. Stable Non-Forest: Non-Forest remaining as non-forest

Carbon emission from forest loss (deforestation) and carbon sequestration from forest gain (afforestation) was calculated on the basis of TNC Report. Whereas, carbon sequestration from stable forest was calculated according to SNC Report. The method of estimating emission and sequestration is based on the:

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

Table 5: Growth rate by vegetation type

S.N.	Physiographic Zone	Equivalent Vegetation Zone	Growth rate kt dm/ha/year by sources		
			MPFS (1998)	WECS (2010)	IPCC (2003)
1	High Himal	Montane dry	3.872	5.8	1.5
2	High Mountain	Montane moist	4.635	5.8	1.0
3	Middle Mountain	Dry	3.086	7.9	1.0
4	Siwalik	Tropical moist with long dry season	5.389	9.6	3.0
5	Terai	Tropical wet/very moist	7.418	9.6	3.4

Source: LENS, 2022

For estimating the CO_2 sequestration from stable forest, we adopted the method applied in SNC. The growth rate of vegetation has a significant contribution to the country's CO_2 sink. However, at

present, the growth rate of Nepal's forest as per the IPCC defined criteria is not available. The growth rate of Nepal's forest estimated by different agencies varies widely (Table 5).

While choosing of Tiers for derivation of methods, a country should adopt the values of the country, if available. In our case, we have two values provided from reports of Master Plan for Forest Sector (MPFS) and WECS. MPFS values are based on intensive field-based research while WECS values are limited to growth rate based on growth condition of forest below 25 years. Therefore, the MPFS values (growth rates) are adopted in this report (following SNC report). Furthermore, although vegetation of Nepal has been classified using the IPCC (2006) criteria, there is a lack of corresponding forest inventory data. To overcome this shortcoming, the five physiographic zones are considered to be the close representatives of the five vegetation zones.

The refined land use dataset (2010 and 2019) provided by FRTC were used to calculate the annual carbon stock change in this report. Corresponding default emission factors and other data were used from the guideline evaluating the country specific climatic zones, physiographic range and forest types (ecological domain). The National Forest Reference Level Report of Nepal (2000-2010) (MoFSC, 2017) and TNC report was considered as a guiding framework to calculate carbon emission and carbon sequestration from forest loss and forest gain.

Table 6: Forest change matrix showing forest loss and forest gain between 2010 and 2019 (in ha)

		2010		
	Land cover type	**Forest**	**Non-Forest**	**Grand Total**
2019	**Forest**	849811.2136	61946.41018	**911757.6238**
	Non-Forest	26400.69613	1262003.77	**1288404.466**
	Total	**876211.9098**	**1323950.18**	**2200162.09**

Source: FRTC, 2015; FRTC, 2022

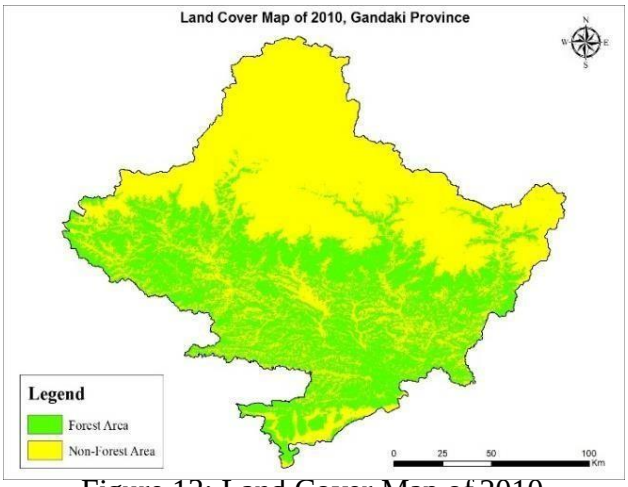


Figure 13: Land Cover Map of 2010

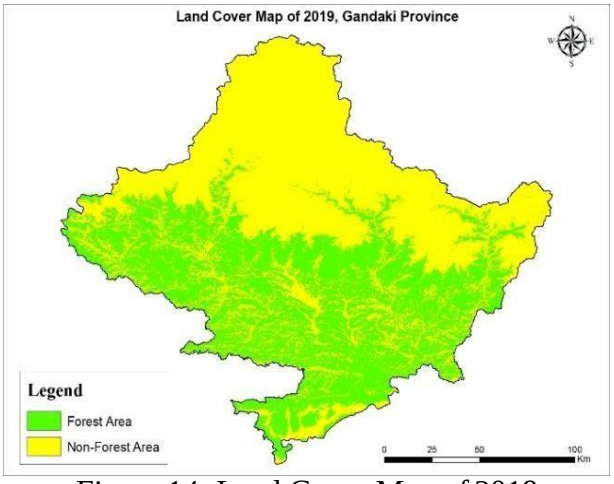


Figure 14: Land Cover Map of 2019

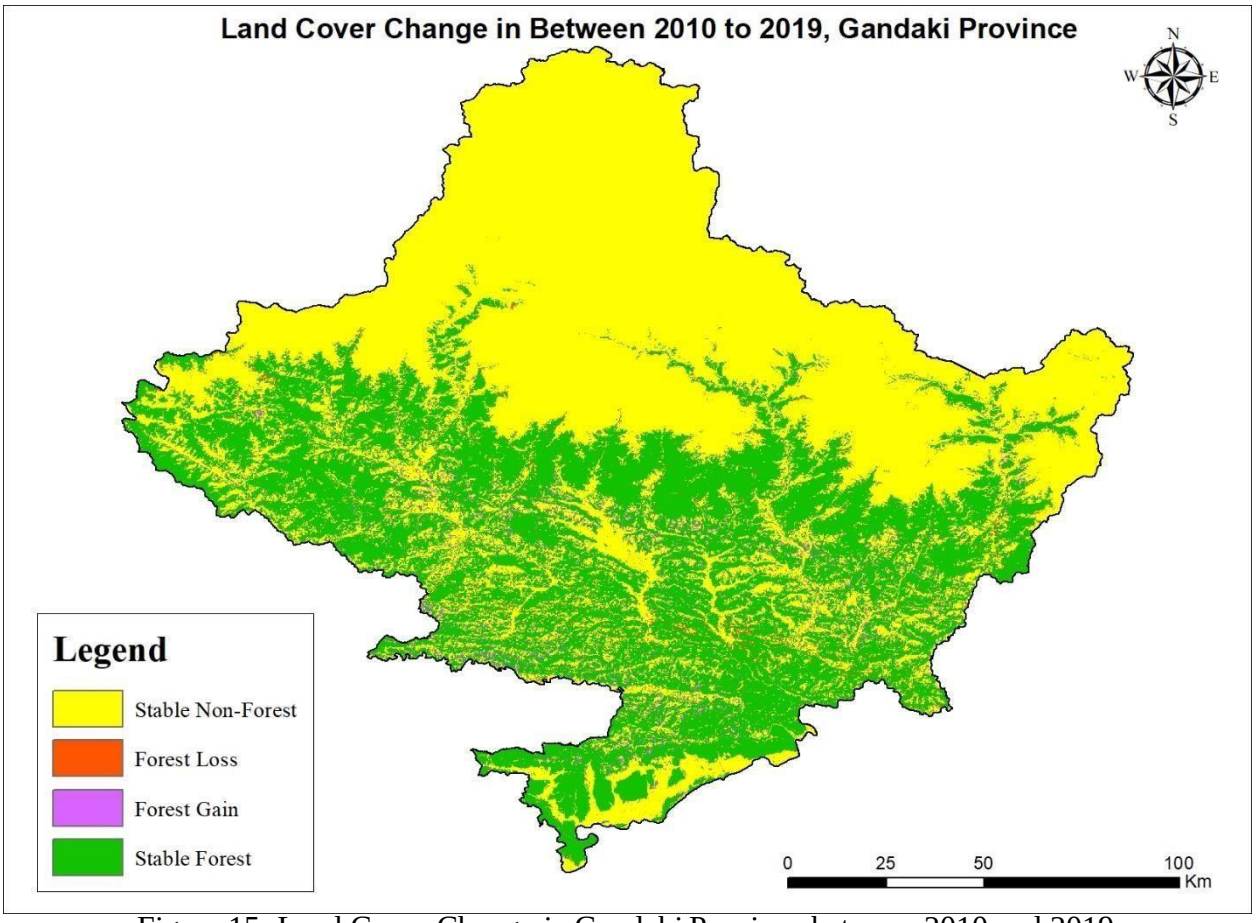


Figure 15: Land Cover Change in Gandaki Province between 2010 and 2019

MODIS was used to calculate the forest fire in between the years 2015-2022. The MODIS Fire_cci Burned Area pixel product version 5.1 (FireCCI51) is a monthly global ~250m spatial resolution dataset containing information on burned area as well as ancillary data.

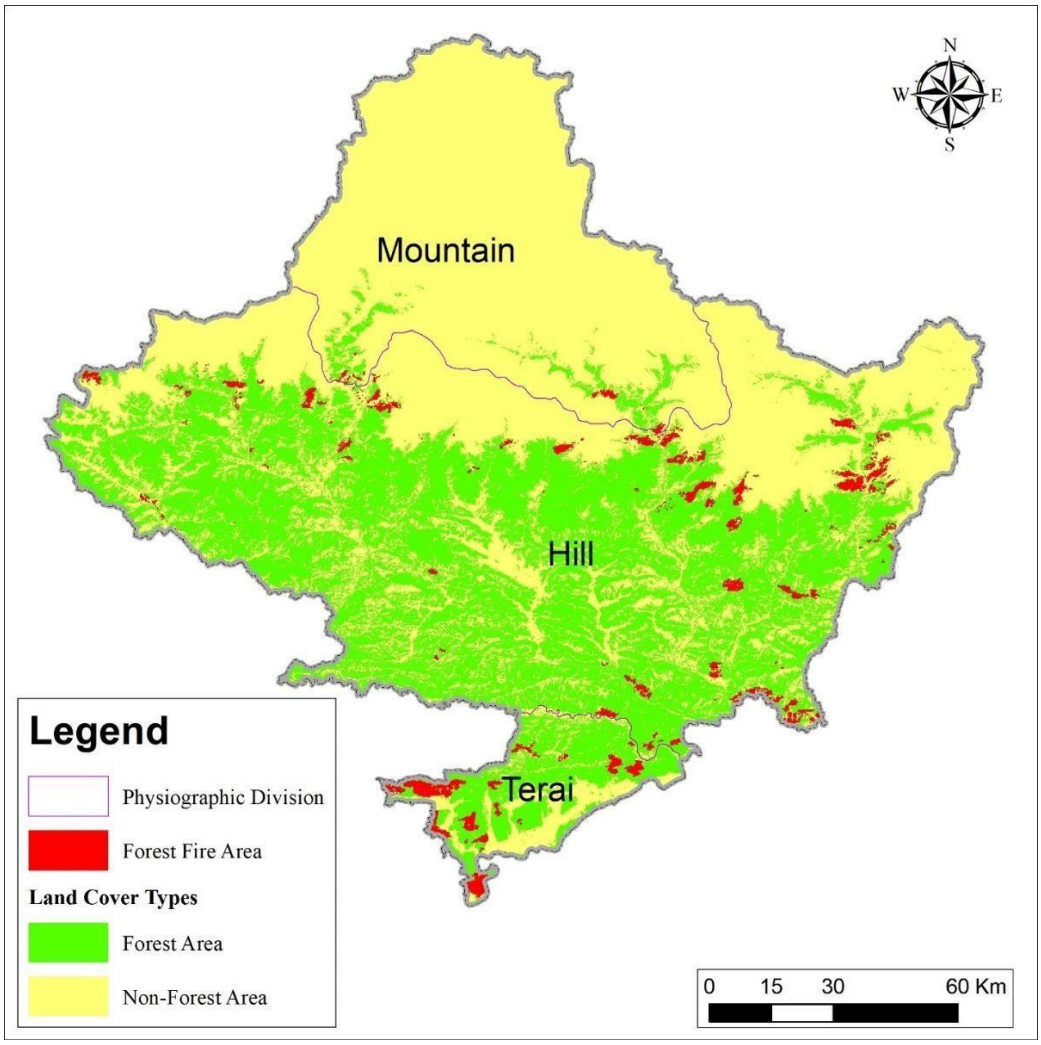


Figure 16: Forest fire area in Gandaki Province between 2015 and 2022

In the areas where forest land remained intact (forest land), emissions of CO_2 from biomass burning need to be accounted for, because they are generally not synchronous with rates of CO_2 uptake. According to IPCC 2006, generic approach was used to estimate CO_2 emissions from fire.

Estimation of Carbon emission from fire

$$L_{fire} = A * M_b * C_f * G_{ef} * 10^{-3}$$

Where:

L_{fire} = amount of Carbon emissions from fire, tonnes

A = area burnt, ha

M_B = mass of fuel available for combustion, tonnes ha-1.

C_f = combustion factor, dimensionless

G_{ef} = emission factor, g kg-1 dry matter burnt

Note: Where data for M_B and C_f are not available, a default value for the amount of fuel actually burnt (the product of M_B and C_f) can be used under Tier 1 methodology**.** For this, in our calculation default value of primary tropical forest was used for terai forest fire whereas, wildfire subcategory of other temperate forest was used for hill and mountain fire which default value was given by IPCC, 2006. For emission factor (G_{ef}), extra tropical forest category is used for the calculation of total carbon emission from the forest fire in the Gandaki Province.

Table 7: Forest change across physiographic regions of Gandaki Province

Physiographic Regions	**Forest Loss**		**Forest Gain**		**Total Change**		**Stable Forest**		**Stable Forest**	**Non-**
	Area Ha	**%**	**Area Ha**	**%**	**Area Ha**	**%**	**Area Ha**	**%**	**Area Ha**	**%**
High Himal	3416.9	12.9	4334.8	7.0	7751.7	8.8	43897.7	5.2	916521	72.62
High Mountain	8403.5	31.8	14395.05	23.2	22798.6	25.8	334275.5	39.3	125510.5	9.95
Middle Mountain	14093.3	53.4	40089.96	64.7	54183.2	61.3	410855.3	48.3	182562.9	14.47
Siwalik	487.05	1.8	3126.6	5.0	3613.7	4.1	60782.7	7.2	37244.34	2.95
Terai	0	0.0	0	0.0	0	0	0	0	165.03	0.01
Grand Total	**26400.7**		**61946.4**		**88347.1**		**849811.2**		**1262004**	

Source: LENS, 2022

The table 7 shows the distribution of change area and stable forest/non-forest area across physiographic regions of Gandaki Province.

The activity data on total annual forest loss and forest gain is calculated by dividing total forest loss and gain across physiographic region in ten years by ten. Emission and sequestration factors applied for deforestation (forest loss) and afforestation (forest gain) respectively were used as used by TNC, which were sourced from the NFI of 2010-14 (DFRS, 2015) and IPCC (2006) guidelines.

4.3 Carbon Emission from AFOLU Sector

The total emission of carbon in this sector is 1339.8 Gg CO_2-eq/year. This is only 10% of emissions from AFOLU sector as mentioned in TNC). The total sequestration is -2,330.7Gg CO_2-eq/year (based on table 8 and 9) which is only nearly 10% of the sequestration from AFOLU sector as mentioned in TNC). The annual emissions and removals due to deforestation and afforestation are 1144.2 Gg CO_2-eq/year and -673.3 Gg CO_2 -eq/year, respectively. The total emission from forest fire was 195.6 Gg CO_2 -eq/year. This research did not consider carbon emission from degradation.

Table 8: Total carbon sequestration through stable forest

Forest category	Area of forest/ biomass stocks (K ha)	Annual growth rate (t dm/ha)	Annual biomass increment (Kt dm)	Carbon fraction of dry matter	Total carbon uptake (Kt c)	Total carbon uptake (Gg CO_2-eq/yr)
High Himal	43.9	3.872	170.0	0.5	85.0	85.0
High Mountain	334.3	4.635	1549.4	0.5	774.7	774.7
Mid Mountain	410.9	3.086	1267.9	0.5	633.9	633.9
Siwalik	60.8	5.389	327.6	0.5	163.8	163.8
Total						**1657.4**

Source: LENS, 2022

The default value of carbon fraction of dry matter adopted is 0.5 (according to SNC).

Table 9: Annual CO_2 eq (Gg) sequestration due to forest gain (Afforestation)

Physiographic Region	Sequestration per ha (tCO2eq/ha)	Annual gain in ha – (Total Gain Area/ 10)	Annual sequestration from afforestation (2010-2019)- (Gg CO_2-eq/yr)
High Himal	160.81	433.5	69.7
High Mountain	160.81	1439.5	231.5
Middle Mountain	84.87	4009	340.2
Siwalik	102.02	312.7	31.9
Total			**673.3**

Source of default value of sequestration: FRL (2000-2010)

Table 10: Annual CO_2 eq (Gg) emission due to Forest Loss (Deforestation)

Physiographic Region	Emissions per ha (tCO2eq/ha)	Annual loss in ha – (Total Loss Area/ 10)	Annual emissions from deforestation (2010-2019)- (Gg CO_2-eq/yr)
High Himal	584.77	341.7	199.8
High Mountain	584.77	840.4	491.4
Middle Mountain	308.61	1409.3	434.9
Siwalik	370.97	48.7	18.1
Total			**1144.2**

Source of default value of emission: FRL (2000-2010)

Table 11: Annual average CO2 e (Gg) emission from forest fire (2015-2021)

Physiographic Region	Area Burnt (ha.)	Amount of Fuel Combusted (M_b*C_f) (tonnes per ha.)	Emission Factor (G_{ef})[g GHG (kg dm burnt)$^{-1}$]	Total Emission (Gg CO_2-eq/yr)
Siwalik	189.7	42.2	1569	12.6
Hill	3953.3	19.8	1569	122.8
Mountain	1938.8	19.8	1569	60.2
Total				**195.6**

Source default value of M_b, C_f and G_{ef} : IPCC 2006

CHAPTER 5: WASTE SECTOR

5.1 Overview of the sector

In majority of the rural parts of Nepal, systematic waste management system has not yet been practiced. Waste disposal is haphazard (thrown in field, roadside, etc.) with no anaerobic processing. As anaerobic condition doesn't develop, emission is mostly CO_2. Consistent with the 1996 Guidelines (IPCC, 1997), only CO_2 emissions resulting from oxidation, during incineration and open burning of carbon in waste of fossil origin (e.g., plastics, certain textiles, rubber, liquid solvents, and waste oil) are considered net emissions. The practice of Municipal Solid Waste (MSW) incineration is currently more common in developing countries. So, for this inventory only incineration and open burning of MSW is considered. Open burning of waste can be defined as the combustion of unwanted combustible materials such as paper, wood, plastics, textiles, rubber, waste oils and other debris in nature (open-air) or in open dumps, where smoke and other emissions are released directly into the air without passing through a chimney or stack. Emissions from waste incineration without energy recovery are reported in the Waste Sector.

5.2 Data and Methods

5.2.1 Data

The inventory adopted 2006 IPCC guidelines, which provide guidance on data collection, methodological choices and use of assumptions. In events of complete absence of data for the activities, expert judgment was used and assumptions documented. There is a dearth of comprehensive and reliable data on solid waste sector in Gandaki Province. Few studies conducted by different agencies show that the results are not matching with each other in national scenario. Similarly, demographic information from previous census cannot be directly compared with 2011 data because status of many villages has been changed into municipalities but they still retain some rural characteristics.

Various national and international sources were used to obtain data for this report. Information about population was obtained from national census (CBS, 2011) and solid waste from Kaza et al. 2018; UNDESA 2019 and World Bank 2020. According to the World Bank's What a Waste 2.0–*A Global Snapshot of Solid Waste Management to 2050* study, Nepal generated nearly 1.8 million tonnes of waste in 2016. It is estimated that MSW generation in Nepal will increase to 2.2 million tonnes in 2030 and over 2.9 million tonnes in 2050, based on current

urbanization and population growth rates (Kaza et al. 2018). Nepal's MSW generation of 0.17 kg per person per day is considered and same assumption is made on the Provincial basis.

5.2.2 Methodology

The inventory adopted Tier 1 methodologies to estimate carbon emission from waste sector. In case of unavailability of provincial specific data, data from reliable national and international sources were used. In case of gaps, appropriate statistical methods (e.g., trends extrapolation, interpolation, etc) were applied in practice with IPCC guideline. The common method for estimating CO_2 emissions from incineration and open burning of waste is based on an estimate of the fossil carbon content in the waste combusted, multiplied by the oxidation factor, and converting the product (amount of fossil carbon oxidized) to CO_2. The activity data are the waste inputs into the incinerator or the amount of waste open-burned, and the emission factors are based on the oxidized carbon content of the waste that is of fossil origin. Relevant data include the amount and composition of the waste, the dry matter content, the total carbon content, the fossil carbon fraction and the oxidation factor. The activity data is calculated on the basis of World Bank 2020 report and only Municipal Solid Waste is considered in this inventory. As detail data to pinpoint exact quantity and nature of open burning is not available, 10% of total solid waste is assumed to be open burned as in the Third National Communication Report.

Based on the total amount of waste combusted.

$$\textbf{CO}_2\textbf{ Emission} = \sum_i (\boldsymbol{SWi} * \boldsymbol{dmi} * \boldsymbol{CFi} * \boldsymbol{FCFi} * \boldsymbol{OFi}) * \mathbf{44/12}$$

Where:

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

SWi = total amount of solid waste of type i (wet weight) incinerated or open-burned, Gg/yr

dmi = dry matter content in the waste (wet weight) incinerated or open-burned, (fraction)

CFi = fraction of carbon in the dry matter (total carbon content), (fraction)

FCFi = fraction of fossil carbon in the total carbon, (fraction)

OFi = oxidation factor, (fraction) 44/12 = conversion factor from C to CO_2

i = type of waste incinerated/open-burned specified as follows: MSW: municipal solid waste, ISW: industrial solid waste, SS: sewage sludge, HW: hazardous waste, CW: clinical waste, others (that must be specified)

5.3 Carbon Emission from Waste Sector

Open Burning is practiced waste management system in Gandaki Province from household level to institutional level. The total carbon emission from the waste sector of Gandaki Province is 0.07 Gg CO_2- eq. (Table 12).

Table 12: CO_2 emission from open burning of waste

Waste open burned (Gg)	Dry matter content (Fraction)	Carbon in Dry Matter (Fraction)	Fraction of Fossil Carbon in Total Carbon	Oxidation Factor	Total CO_2 emission (Gg/Yr) in Gandaki Province
1.49	0.78	0.34	0.08	0.58	**0.07**

Source: LENS, 2022

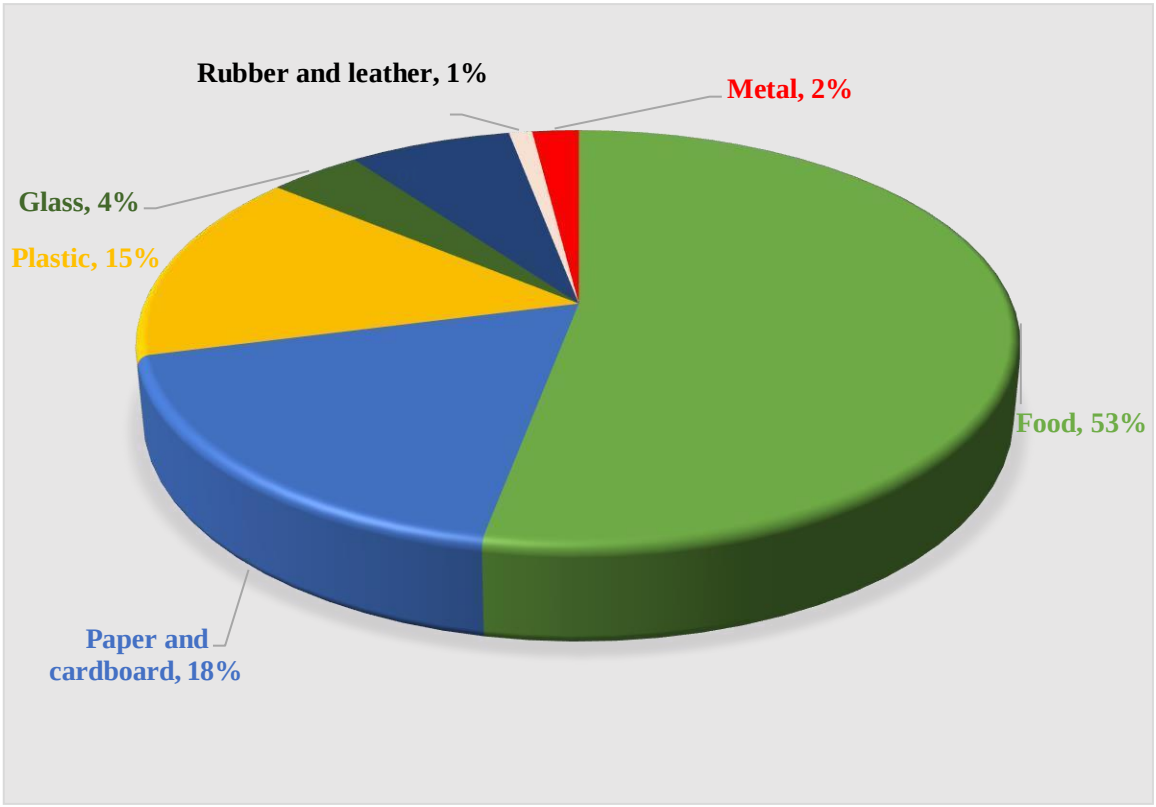


Figure 17: MSW composition of Gandaki Province (World Bank report, 2016)

MSW primarily constitutes biodegradable (organic) waste. According to the What a Waste 2.0 (2018) report, 53 percent of MSW comprises biodegradable waste (food and garden/green waste). Paper and cardboard are another important waste category at 18%, while plastic waste, another important waste stream due to its ability to pollute waterways and longevity in the environment, constitutes 15% (Kaza et al. 2018). Probably, this 15% of the waste helped increase the carbon emission and needs to be checked to reduce carbon emission from waste. Figure 15 illustrates the MSW composition in Nepal from the What a Waste 2.0 (2018) study.

CHAPTER 6: EMISSION OF CARBON FROM VARIOUS SECTORS IN GANDAKI PROVINCE

Among the four sectors, energy sector (2040.49 Gg CO_2- eq) contributed the most and waste sector (0.07 Gg CO_2- eq) the least. Industries contributed the most followed by AFOLU in raising the amount of carbon emission in Gandaki province (Fig. 18).

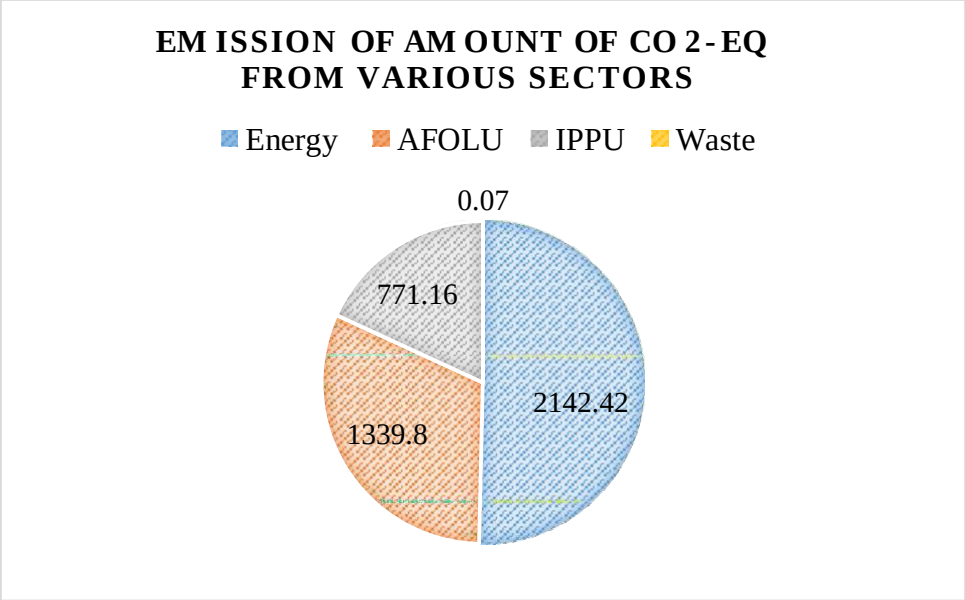


Figure 18: Emission of amount of carbon dioxide equivalent from various sectors

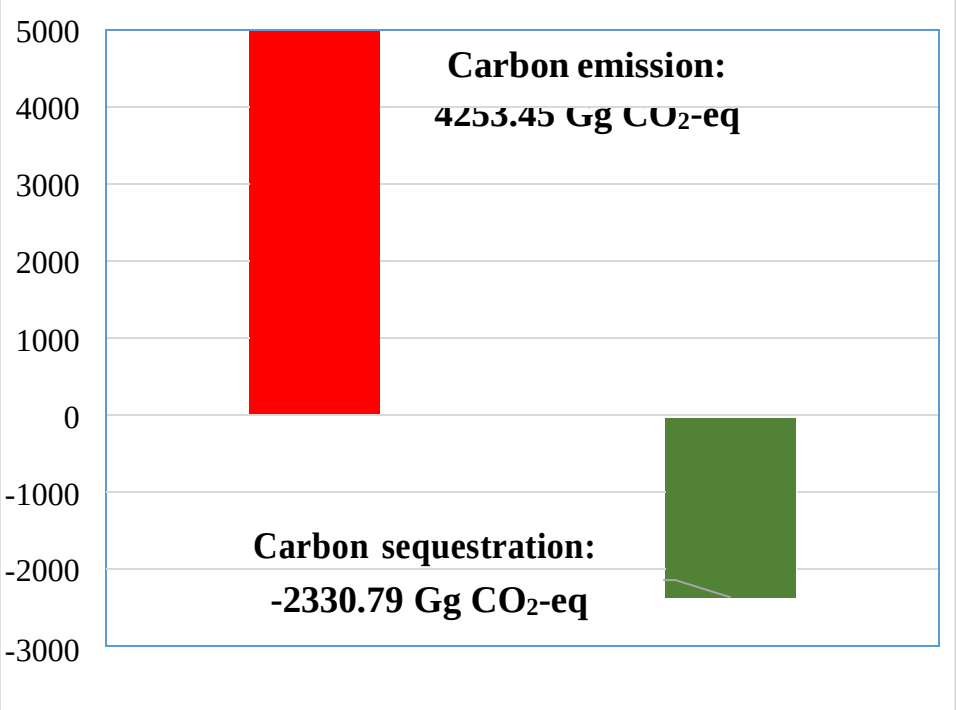


Figure 19: Annual Carbon emissions and sequestration in Gandaki province (Gg CO_2 -eq /year)

CHAPTER 7: CONCLUSION AND RECOMMENDATION

7.1 Conclusion

The total amount of carbon emission from Energy sector, AFOLU sector, IPPU sector and Waste sector are 2,142.42, 1339.8, 771.16 CO_2-eq and 0.07 emission of CO_2-eq (Gg) respectively. Energy sector contributed the most for carbon deposition in the atmosphere. The net carbon emissions estimated was 4253.45Gg CO_2-eq and carbon sequestration of 2330.79Gg CO_2-eq for Gandaki province.

Due to various research constraints, we could not include carbon sequestration by wetlands and the contribution of harvested wood products (HWP) to annual AFOLU CO_2 emissions/ removals. Hence, though it seems that carbon emission is more than sequestration rate in Gandaki province, but we believe that inclusion of all the areas that sequestrate carbon might prove Gandaki province as a carbon neutral province which could boost tourism and other eco-friendly industries in the province and in the meantime assure a livable province.

7.2 Recommendations

This research is limited to carbon emission and sequestration however, to provide correct scenario of Green House Gas (GHG) and its effect in Gandaki Province, inventory of all the GHGs should be made. In addition, the outcome of the research is solely based on the secondary data which might not provide true scenario of carbon emission and sequestration in the province. Hence, pilot survey in each sector would help to provide robust information and the ways forward. CBS has not yet published the related data required to calculate CO_2 emission and sequestration for 2021/2022. This research used the population data provided by CBS, 2011. In the same way, for energy related calculations we used energy consumption scenario published by WECS in 2014. In near future (probably by 2023), both the reports (documents) might be published so the outcome of the present research should be updated with the availability of latest data.

The recommendations presented here are based on our field observations and information collected from key informants' interview.

Sectors	Recommendations
Energy Sector	• It is observed that fuel wood consumption still is increasing at an unbelievable rate in spite of modernization and supply of LPG gas and electricity in household level. Few reasons we observed for this continued phenomenon are: 1. Easy availability of and access to fuelwood, 2. High cost involved in consumption of LPG gas and electricity. Electricity production is increasing at a skyrocketing speed hence it might be predicted that the cost of electricity is reduced which might help people to consume electricity rather than fuelwood. • This research found that emission from transportation sector is substantial hence if the province could introduce plans and policies that promote electric vehicles (like provision of subsidy to buy electric vehicles), introduce pedestrian friendly walkways, non-motorized transport system (like cycling) and systematize public transport system the emission level from this sector could be easily reduced. • Vehicle emission test should be conducted regularly so as to reduce emission from transport sector • Prepare plans and policies that bind industrialists to use alternative sources of energy • Promotion of green enterprises
IPPU	• Cement Industries established in Gandaki Province produce immense amount of carbon, hence this has to be solved for making this Province carbon neutral or carbon minus. In the developed country like Australia, Canada, Denmark, UK, US, they have been adopting an advanced technique of Carbon Capture and Storage (CCS) system, additionally encouraged by Conference of Parties (CoP)-26. Though, it seems to be less feasible in our country at the present, but if planned well, developing country like ours may also be able to adopt this way of managing carbon emitted from cement industry. • Gandaki Province produces approximately 149,153 tonnes of waste and most of the wastes are inorganic and could be burnt to generate electricity through incineration. The generated electricity can in turn fuel the industrial sector and reduce the consumption of fossil fuels in industrial sector.

AFOLU	• Plantation in urban open spaces and on both sides of roads • Prepare mechanisms to prohibit and control forest fire • Integrate urban forestry and urban forestry plans as an integral component of urban planting by municipalities through legal provisions and through bylaws on creation of open space (Forestry sector strategy (2016-2025)). • Forest based industries should be promoted • Going along with mitigation component of NDC, restore and manage degraded forest land. • Growing stock could be increased by sustainable management of forest with appropriate silviculture system through implementing management plan (Forestry sector strategy (2016-2025)). • According to United Nations Convention to Combat Desertification, we should not increase the forest area by planting fast growing trees species because such species tend to harm ecosystem, hence Gandaki Province should decide rationally when choosing plants for afforestation.
Waste	• Conduct awareness programs to reduce burning of waste and also ban open burning of waste • Instead of burning waste openly, the government may draft plans and policies that promote incineration of waste adopting systematic methods/technology to produce energy out of it or could be sent to recycling plant.

REFERENCES

CBS (2011). Nepal Living Standard Survey 2010/2011, Statistical Report. Central Bureau of Statistics, Kathmandu.

CBS (2012). National Population and Housing Census 2011(National Report). Central Bureau of Statistics.

CBS (2016). 2015 Statistical Year Book Nepal. Kathmandu: Central Bureau Statistics.

CBS (2021). National Population and Housing Census 2011(National Report). Central Bureau of Statistics.

DFRS (2015). State of Nepal's Forest's. Kathmandu: Department of Forest and Research Survey.

DoI (201/2020). Industrial Statistics. Department of Industry.

IPCC 2001. Climate Change 2001: The Scientific Basis. Contribution of Working IPCC. The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, 881 pp.

IPCC (2006). Guidelines for National Greenhouse Gas Inventories, Intergovernmental panel for climate change (IPCC), Switzerland.

IPCC (Intergovernmental Panel on Climate Change), 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, H.S. Eggleston, L. Buendia, K. Miwa, T. Ngara, and K. Tanabe, eds., prepared by the National Greenhouse Gas Inventories Programme, Institute for Global Environmental Strategies, Hayama, Kanagawa, Japan, 5 volumes.

Karki, K. (2007). Greenhouse gases, global warming and glacier ice melt in Nepal. *Journal Of Agriculture and Environment*, *8*, 1-7. doi: 10.3126/aej.v8i0.721

Kaza, Silpa, L. Yao, P. Bhada-Tata, and F. Van Woerden. 2018. What a Waste 2.0–A Global Snapshot of Solid Waste Management to 2050. October. Washington, DC: The World Bank.

Malhi Y, Meir P, Brown S. 2002. Forests, carbon and global climate. Philos. Trans. R. Soc. A 360(1791):1567–91

MoF (2020b). Economic survey 2019/20. Kathmandu: MoF

MoPE (2004). Nepal Initial National Communication to the United Nations Framework Convention on Climate Change. Kathmandu: Ministry of Population and Environment.

MoPE. (2016). *Nationally Determined Contributions.* Ministry of Population and Environnment.

MoSTE (2014). Nepal Second National Communication to the United Nations Framework Convention on Climate Change. Kathmandu: Ministry of Science, Technology and Environment.

Sedjo, R., & Sohngen, B. (2012). Carbon Sequestration in Forests and Soils. *Annual Review Of Resource Economics*, *4*(1), 127-144. doi: 10.1146/annurev-resource-083110-115941

Sharma, B. (2019). Household Fuel Transition and Determinants of Firewood Demand in Nepal. *Economic Journal of Development Issues*, 83-95. doi: 10.3126/ejdi.v25i1-2.25095

Suocheng, D., Tong, K.W., Yuping, W., 2001. Municipal solid waste management in China: using commercial management to solve a growing problem. Utilities Policy 10, 7–11.

TEPC (2020). Export Import Data Bank Version 1.5. Trade and Export Promotion Centre, Ministry of Commerce and Supplies, Government of Nepal, Lalitpur, Nepal.

UNDESA (United Nations Department of Economic and Social Affairs). 2019. "World Population Prospects 2019: Highlights." June. New York: Population Division, UNDESA. https://population.un.org/wpp/Publications/Files/ WPP2019_10KeyFindings.pdf.

WECS (2010). Energy Sector Synopsis Report 2010. Water and Energy Commission Secretariat (WECS), Kathmandu, Nepal.

WECS (2014). Energy Data Sheet 2014. Water and Energy Commission Secretariat (WECS), Kathmandu, Nepal.

World Bank. 2019. "Solid Waste Management." Washington, DC: The World Bank. https://www.worldbank.org/en/topic/ urbandevelopment/brief/solid-waste-management.

World Bank. 2020. "World Bank Open Data." Washington, DC: The World Bank. https://data.worldbank.org.

ANNEX

Annex 1: List of office visited in Gandaki Province

District	Office Visited
Baglung	• Division Forest office • Baglung Chamber of commerce and industry • Baglung Municipality • Department of transport management
Kaski	• Pokhara Chamber of Commerce and Industry • Ministry of Energy, Water Resource and Irrigation • Pokhara Metropolitan City Office (Environment and Sanitation section). • Department of small and cottage industry • Division Forest Office • Forest Directorate Office, Gandaki Province, Pokhara • Ministry of Physical Infrastructure Department, Gandaki Province, Pokhara
Parbat	• Division Forest Office • Kushma Municipality office • Parbat Chamber of Commerce and Industry • Agriculture Knowledge Center
Syangja	• Putalibazar Municipality Office • Transport Management Office • Syangja Chamber of Commerce and Industry • Department of Small and Cottage Industry • Agriculture Knowledge Center • Division Forest Office

Tanahun	• Byas Municipality, Damauli • Division Forest Office • Department of Small and Cottage Industry • Agriculture Knowledge Center

Annex 2: List of stakeholders of Key Informant Interview

S.N.	Name of Key Informants	Post	Address
1	Mukunda Prasad Adhikari	DFO	Division Forest Office, Baglung
2	Madan Kandel	AFO	Division Forest Office, Baglung
3	Deepak Sharma	Administrative Officer	Division Forest Office, Baglung
4	Narayan Raj Sapkota	Assistant	Division Forest Office, Baglung
5	Bal Bahadur Ale	Forester	Division Forest Office, Baglung
6	Hari Narayan Upadhaya	Computer Assistant	Baglung Municipality
7	Humkala Sinjali	Assistant Sub Engineer	Baglung Municipality
8	Jyoti Nepali		Baglung Municipality
9	Dhan Prasad Pokharel	Administrative Officer	Baglung Municipality
10	Sas Bahadur Pun	Officer (6^{th} Level)	Baglung Municipality
11	Tulsiram Kandel	Officer (6^{th} Level)	Department of Transport Management, Baglung
12	Rita Rana Pun		Department of Transport Management, Baglung
13	Badrinath Gautam	Officer	Department of Transport Management, Baglung
14	Naresh Kandel	General secretary	Baglung Chamber of Commerce and Industry

15	Saraswati Khatri	Secretary	Baglung Chamber of Commerce and Industry
16	Ram Krishna Poudel	Secretary	Baglung Chamber of Commerce and Industry
17	Anil Subedi	Officer (7^{th} Level)	Ministry of Energy, Water Resource and Irrigation, Pokhara
18	Ram Prasad Chapagain	Acting Officer	Ministry of Energy, Water Resource and Irrigation, Pokhara
19	Nirmal Man Singh Bhandari	Officer	Pokhara Metropolitian (Environment section)
20	Mankala Poudel	*Nayab subba*	Pokhara Metropolitian (Environment section)
21	Harka Bahadur Gayal	*Nayab subba*	Pokhara Metropolitian (Sanitation section)
22	Maharaj Dhakal	Industrial Officer	Department of Small and Cottage Industry, Pokhara
23	Bishwo Raj Gurung	Computer Operator	Department of Small and Cottage Industry, Pokhara
24	Madhuri Khadka	AFO	Division Forest Office, Kaski
25	Indra Prasad Adhikari	Acting forest Director	Forest Directorate Office, Gandaki province, Pokhara
26	Tilak Bahadur Thapa	AFO	Forest Directorate Office, Gandaki province, Pokhara

27	Sunil Chhetri	Administrator	Pokhara Chamber of Commerce and Industry
28	Kedar Sapkota	Officer	Ministry of physical Infrastructure Department, Gandaki Province, Pokhara
29	Megharaj Poudel	DFO	Division Forest Office, Parbat
30	Keshab Pudasaini	AFO	Division Forest Office, Parbat
31	Dhurba Raj Poudel	Officer (7^{th} level)	Kushma Municipality
32	Ashish Shakya	Engineer	Kushma Municipality
33	Shiv Raj Baral	Engineer	Kushma Municipality
34	Gopi Adhikari	Chairman	Parbat Chamber of Commerce and Industry
35	Thakur Bikram Poudel	Chairman	Parbat Chamber of Commerce and Industry
36	Ghanshyam Upadhaya	-	Parbat Chamber of Commerce and Industry
37	Tankanath Poudel	Chief	Parbat Chamber of Commerce and Industry
38	Ramesh Sharma	General Secretary	Parbat Chamber of Commerce and Industry
39	Bishnu Giri	Acting Secretary	Parbat Chamber of Commerce and Industry
40	Manita Thapa	Chief	Agriculture Knowledge Center, Parbat

41	Bishwash Kaphle	Agricultural Officer	Agriculture Knowledge Center, Parbat
42	Kamana Neupane	Technical Assistant	Agriculture Knowledge Center, Parbat
43	Shirjana Khanal	Agriculture Assistant	Agriculture Knowledge Center, Syangja
44	Haribansa Neupane	DFO	Division Forest Office, Syangja
45	Amar Bahadur Parajuli	AFO	Division Forest Office, Syangja
46	Dhan Prasad Koirala	Section Officer	Environment, Sanitation and National Disaster Risk Reduction and Management Authority, Putalibazar
47	Basanta Bhusal	Mechanical supervisor	Transport Management Office, Syangja
48	Binita Hamal Dhital	Secretary	Syangja Chamber of Commerce and Industry
49	Rameshowr Acharya	Accountant	Department of Small and Cottage Industry, Syangja
50	Prakash Karki	*Kharidaar*	Department of Small and Cottage Industry, Syangja
51	Krishna Lamsal	Computer Operator	Department of Small and Cottage Industry, Syangja
52	Ishwari Prasad Aryal	Technical Agriculture Officer	Agriculture Knowledge Center, Syangja

Annex 3: List of Experts consulted at central level

S.N.	Name of Key Informants	Post	Address
1	Keshab Raj Goutam, PhD	Technical advisor at Ecosystem and Forest Type Mapping, Forest Research and Training Center	Babarmahal, Kathmandu
2	Milan Dhungana	Research Officer, Forest Research and Training Center	Babarmahal, Kathmandu
3	Rajaram Aryal	Assistant Research Officer, Forest Research and Training Center	Babarmahal, Kathmandu
4	Amul Acharya	Assistant Research Officer, Forest Research and Training Center	Babarmahal, Kathmandu
5	Assoc. Prof. Sudeep Thakuri	Dean, Faculty of Science and Technology, Mid-Western Universityf	Surkhet, Nepal
6	Utsab Rajbhandari,	Energy Expert	Kathmandu

Annex 4: Emission factors for fuels

Sector	Fuels	CO_2 (Kg/Tj)
Residential	Fuel wood	112000
	Kerosene	71900
	LPG	63100
	Biogas	54600
Transportation	Diesel	74100
	Motor spirit	69300
Agriculture	L diesel	74100
	H S diesel	74100
Commercial	Wood	112000
	Kerosene	71900
	LPG	63100

Source - IPCC (1996, 2001, 2006), Ramachandra and Shwetmala (2009)

Annex 5: Average annual kilometer travelled and energy intensity

Fuel	Vehicle	Average Annual km	Energy Intensity, km/l
Diesel	Truck/Bus/Mini Bus	50336	5.695
Diesel	Jeep/van	31143	8.942
Diesel	Tractor	17791	5.356
Motor spirit	Car	23097.5	11.238
Motor spirit	Two-wheeler	10550	44.448
Motor spirit	Three-wheeler	15989	6.463

Source: WECS, 2000; Second National Communication (SNC)

Annex 6: Worksheet

Table 1: Worksheet of CO_2 emission from transportation sector

Vehicle type	Average annual km (SNC)	Energy intensity (km/l)	Carbon emission factor (kg CO_2/TJ)	Constant factor (J)
Bus/minibus/truck/ minitruck	50336	5.695	74100	38000000
Jeep/car/van/micro bus	23097.5	11.238	74100	38000000
Tractor/power tailor	17791	5.356	74100	38000000
Motorcycle/Scooter	10550	44.448	69300	34200000
Three-wheeler	15989	6.463	69300	34200000

Table 2: Worksheet of CO_2 emission from residential sector

Fuel Type	Energy consumption in residential sector (TJ)	Emission Factor (kg CO_2/TJ)
Wood/firewood		112000
Kerosene		71900
LPG Gas		63100
Bio-gas		54600

Table 3: Worksheet of CO_2 emission from agricultural sector

Fuel Type	Energy Consumption by agricultural sector (TJ)	Emission factor (kg CO_2/TJ)
Diesel		74100
Motor spirit		74100

Table 4: Worksheet of CO_2 emission from commercial sector

Fuel Types	Energy consumption by commercial sector (TJ)	Emission Factor (kg CO_2/TJ)
Fuelwood		112000
LPG gas		63100
Diesel		74100
Kerosene		71900
Motor spirit		74100
Coal		92600

Table 5: Worksheet of CO_2 emission from industrial sector

Fuel Types	Energy consumption by industrial sector (TJ)	Emission Factor (kg CO_2/TJ)
Coal		92600
Diesel		74100
Motor spirit		74100
Kerosene		71900
Fuel wood		112000
Other Petroleum		74100

Table 6: Worksheet of CO_2 emission from IPPU sector

Name of Industry	District	Install capacity (TDP)	Clinker Fraction	Emission Factor
C.G. cement Industry pvt. ltd	Nawalparasi	250	0.65	0.52
Hongshi Shivam cement pvt. ltd	Nawalparasi	6000	0.65	0.52

Table 7: Worksheet of CO_2 sequestration from stable forest

Forest category	Area of forest/biomass stocks (K ha)	Annual growth rate (t dm/ha)	Annual biomass increment (Kt dm)	Carbon fraction of dry matter
High Himal		3.872	170.0	0.5
High Mountain		4.635	1549.4	0.5
Mid Mountain		3.086	1267.9	0.5
Siwalik		5.389	327.6	0.5

Table 8: Worksheet of CO_2 sequestration from Forest gain (Afforestation)

Physiographic Region	Sequestration per ha (tCO2e/ha)	Annual gain in ha (Total Gain Area / 10)	Annual sequestration (2010-2019) (Gg CO2-eq/yr)
High Himal	160.81		
High Mountain	160.81		
Middle Mountain	84.87		
Siwalik	102.02		

Table 9: Worksheet of CO_2 emission from Forest loss (Deforestation)

Physiographic Region	Emissions per ha (tCO2e/ha)	Annual loss in ha (Total Loss Area / 10)	Annual emissions (2010-2019) (Gg CO2-eq/yr)
High Himal	584.77		
High Mountain	584.77		
Middle Mountain	308.61		
Siwalik	370.97		

Table 10: Worksheet of CO_2 emission from Forest Fire

Physiographic Region	Area Burnt (ha.)	Amount of Fuel Combusted (M_b*C_f) (tonnes per ha.)	Emission Factor (G_{ef})[g GHG (kg dm burnt)$^{-1}$]	Total Emission (Gg CO_2-eq/yr)
Terai		42.2	1569	
Hill		19.8	1569	
Mountain		19.8	1569	

Table 11: Worksheet of CO_2 emission from Waste sector

Total open burned waste (Gg)	Dry matter content (Fraction)	Carbon in Dry Matter (Fraction)	Fraction of Fossil Carbon in Total Carbon	Oxidation Factor	44/12	Total CO_2 emission (Gg/Yr)
	0.78	0.34	0.08	0.58	3.667	

Annex 7: Photo Plates

KII with DFO, Baglung

KII at Agriculture Knowledge Center, Parbat

KII with Mr Dhan Prasad Pokharel

KII with DFO, Parbat

KII with an official of FNCCI, Baglung

KII at Kushma Municipality

KII at Agriculture Knowledge Center, Syangja

Provincial Level Workshop at Ministry of Forest, Environment and Soil Conservation, Pokhara

Annex 8: Workshop Participants list

Participants at Inception Workshop

प्रदेश सरकार

वन, वातावरण तथा भू संरक्षण मन्त्रालय

वन अनुसन्धान तथा प्रशिक्षण केन्द्र

गण्डकी प्रदेश, पोखरा

कार्यक्रमको नाम: गण्डकी प्रदेशमा अवस्थित हुने जम्मा कार्बन उत्सर्जन तथा संचितिकरणको आकलन

विषय: Inception Workshop

मिति: २०७८/१०/०२

उपस्थिती

सि.नं.	नाम थर	पद	कार्यालय	सम्पर्क नं	हस्ताक्षर
१.	घनश्याम ढकाल	उप-सहायक	पूर्वाञ्चल वन निर्देशनालय	९८५३०२५६०२	
२.	अशोक पुनेदी	सिनियर आर्किटेक्ट	आन्तरिक सुरक्षा तथा आचारसंहिता	९८५३०१००६२	
३	सुमन मजुरार्इ	उप-प्रा	बे. वि अ. सं प्रशिक्षण व्यायपस, पोखरा,	९८५२०६१२०६	
४.	निर्मला सिंह भण्डारी	स.वं.अ.	वन विठ प्रयोगशाला तथा अनुसरण केन्द्र	९८५६००६०५६	
५	कपिल ढुङ्गाना	मी.प्रा.सि. अ.	वन, वातावरण तथा भू. संरक्षण मन्त्रालय	९८४६१०७३२०	
६.	रण बहादुर चन्द	कार्यालय सहयोगी	ताल प्राधिकरण, पोखरा	९८४१७०६०५४	
७.	[illegible]	[illegible]	[illegible]	९८५८५०१३५४	
८.	तेज कुमार श्रेष्ठ	LENS	LENS	९८५११२७५४४	
९.	लक्ष्मण कुँवर	रिसर्चर	LENS	९८४६४२०८९०	
१०.	राजेश पोडेल	वि.तो.अ.	वन अनुसन्धान तथा प्रशिक्षण केन्द्र	९८५७६-५०५२१५	
११.	मल्लु के.सी.	वि.अ.अ.	" "	९८४ ६४ ८३६०	
१२.	आँसु ढकाल	अधिकृत	" "		
१३.	गीता कुमारी शर्मा	लेखापाल	" "	९८५६०८२५५८	
१४.	चुडला शर्मा	ड्राइभर	" "	९८४३३२३५५९	
१५.	उत्तम कुवँर	हि.स.चा	" "		
१६.	राज कुमार लम्जाल	का.स.	" "		
१७.	आसरा गौतम	विद्यार्थी	IOF, Pkr		
१८	कालुराज गोर्खाली	अ.प्रा	LENS		

Participants at Provincial Level Workshop

प्रदेश सरकार
वन, वातावरण तथा भू-संरक्षण मन्त्रालय
वन अनुसन्धान तथा प्रशिक्षण केन्द्र
गण्डकी प्रदेश, पोखरा

कार्यक्रमको नाम : गण्डकी प्रदेशमा अवस्थित हुने जम्मा कार्बन उत्सर्जन तथा संचितिकरणको आकलन सम्बन्धी अनुसन्धान कार्यको अन्तरक्रिया कार्यक्रम ।

मिति : २०७९।०२।१३ गते

स्थान : वन, वातावरण तथा भू-संरक्षण मन्त्रालय, गण्डकी प्रदेशको बैठक हल ।

उपस्थिति

सि.नं.	नाम थर	पद	कार्यालय	सम्पर्क नं.	दस्तखत	कैफियत
१.	श्री बद्रिराज ढुंगाना	सचिव	व.वा. तथा भू.सं. मन्त्रालय	९८५६०८५९६६	[illegible]	
२.	श्री रामकाजी श्रेष्ठ	निर्देशक	वन निर्देशनालय	9858422387	[illegible]	
३.	श्री राजेश मल्ल	निर्देशक	व.अ.प्र.के., पोखरा	9851162849	[illegible]	
४.	श्री इन्द्र प्र. अधिकारी	नि. कार्यकारी प्रमुख	ताल सं.त.वि.प्रा.	9849512702	[illegible]	
५.	धर्मेन्द्र कुमार क्षेत्री	उप-सचिव	व.वा. तथा भू.सं.म.	9846467375	[illegible]	
६.	प्रवीण पौडेल	स.अ.सं.अ	" "	९८५६०००२२३	[illegible]	
७.	सरोज पन्थी	स.व.अ.	" "	9867667181	[illegible]	
८.	अशोक पुडेल	स.अ.	अन्नपूर्ण संरक्षण क्षेत्र आ.	9856010065	[illegible]	
९	नविन विश्वकर्मा	[illegible]	पर्यटन उद्योग, व. तथा वा. म.	9856024686	[illegible]	
१०	कमल लामसाल	स.व.अ.	डिभिजन वन कार्यालय	9849405228	[illegible]	
११.	निर्मला सिंह भण्डारी	क.व.अ./का.प्र.	वन विज्ञ प्रयोगशाला तथा प्रशिक्षण केन्द्र	9856077563	[illegible]	
१२	प्रभात भट्टराई	उप-प्राध्यापक	वन विज्ञान अध्ययन संस्थान	9855061006	[illegible]	
१३	मन्जु के.सी.	प्र.अ.सं.	व.अ.प्र.के.	9846483610	[illegible]	
१४.	चुडालाल रोपो	रेन्जर	" "	9843323359	[illegible]	
१५.	जीता कुमारी शर्मा	लेखापाल	" "		[illegible]	
१६.	उत्तम कुँवर	ह.स.चा.	" "		[illegible]	
१७.	निर्मल मान सिंह महर्जन	वातावरण अधिकृत	पोखरा म.न.पा. कार्यालय	९८५६०४९३३६	[illegible]	
१८.	निशान्त लम्साल	का.स.	व.वा. भू.सं. मन्त्रालय			
१९	नरेन्द्र थापा मगर	[illegible]	" "	9848931371	[illegible]	