LAO PEOPLE'S DEMOCRATIC REPUBLIC

PEACE INDEPENDENCE DEMOCRACY UNITY AND PROSPERITY

THE NATIONAL INVENTORY REPORT 2022

Ministry of Agriculture and Environment

2025

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ABBREVIATIONS

AD	Activity Data
AFOLU	Agriculture Forestry and Other Land Use
AP	Agriculture Plantation
Ap1-L	Approach 1-Level Assessment
Ap1-T	Approach 1-Trend Assessment
AR5	IPCC's Fifth Assessment Report
BTR	Biennial Transparency Report
BUR	Biennial Update Report
CCKP	Climate Change Knowledge Portal
CH4	Methane
CL	Cropland
CMA	The Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement
CO2	Carbon Dioxide
CRT	Common Reporting Table
CSOs	Civil Society Organizations
DCC	Department of Climate Change
DD	Dry Dipterocarp Forest
DOF	Department of Forestry
DOP	Department of Planning
DOR	Department of Roads
DPC	Department of Planning and Cooperation
DPF	Department of Planning and Finance
EFs	Emission Factors
EG	Evergreen
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FL	Forest Land
GEF	Global Environment Facility
$GgCO_2eq$	Gigagrams of carbon dioxide equivalent
GGGI	Global Green Growth Institute
GHG	Green House Gases
GL	Grassland
GW	Gigawatt
GWh	Gigawatt hour
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
HWP	1Harvested Wood Products
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industry Process and Production Use
KG	kilogram

LAK	Laotian Kip (Lao currency)
Lao PDR	Lao People's Democratic Republic
LDCs	The Least Developed Countries
LSB	Lao Statics Bureau
LSIS	Lao Statistical Information Service
LULUCF	Land Use, Land-Use Change, and Forestry
MAF	Ministry of Agriculture and Forestry
MCB	Mixed Coniferous and Broadleaved Forest
MCF	Methane correction factor
MD	Mixed Deciduous Forest
MEM	Ministry of Energy and Mine
MOEJ	Ministry of the Environment of Japan
MOEJ	Ministry of the Environment of Japan
MOES	Ministry of Education and Sport
MOIC	Ministry of Industry and Commerce
MONRE	Ministry of Natural Resource and Environment
MPGs	The guiding principles of these modalities, procedures and guidelines
MPI	Ministry of Planning and Investment
MRV	Measurement, Reporting, and Verification
N2O	Nitrous Oxide
NCV	Default Net Calorific Value
NDC	National Determine Contribution
NFMS	National Forestry Monitoring System
NIC	National Inventory Compiler
NIR	National Inventory Reporting
NSEDP	National Socio-Economic Development Plan
ODU	The Oxidized During Use
OH	Other Land
QA	Quality Assurance
QC	Quality Control
REED	Reducing Emissions from Deforestation and Forest Degradation
SE	Sectoral Expert
SL	Settlement
SWDS	Solid Waste Disposal Site
TJ	Terajoule
TNC	Third National Communication
TOW	Total Organic in Wastewater
TWG	Technical Working Group
UNEP	United National on Environment Program
UNFCC	United Nations Framework Convention on Climate Change
WL	Wetland

Foreword

This National Inventory Report (NIR) submitted to the United Nations Framework Convention on Climate Change (UNFCCC), prepared by the Ministry of Agriculture and Environment) on behalf of the National Focal Point for the UNFCCC, the Kyoto Protocol and the Paris Agreement. This NIR is reported in compliance with the Modalities, Procedures, and Guidelines for the Transparency Document Framework for Action and Support Referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex).

This report presents Lao PDR's National Inventory Arrangement, the estimation approach of greenhouse gas emissions and removals from sources and sinks, and the trends in emissions and removals for greenhouse gas, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and Hydrofluorocarbons (HFCs).

The NIR report is prepared in accordance with the Outline of the National Inventory Reporting, Pursuant to the Modalities, Procedures, and Guidelines for the Transparency Framework for Action and Support Referenced in Article 13 of the Paris Agreement (Decision 5/CMA.3 Annex). For this NIR report, Lao PDR, as a country in the Group of Least Developed Countries (LDCs) with a base year of 2022, is applying the flexibility provided under Paragraph 58 of MPGs.

The key structure comprises The Executive Summary (provides information on national emissions and removal trends by gases and sectors and descriptions of Key Categories Analysis); Chapter I (provides background information on Lao PDR's greenhouse gas inventory and climate change; a description of national circumstance and inventory arrangement, brief general description of methodologies, description of key categories and QA/QC plan); Chapter II (Provided the latest information on trends in emissions and removals gases in Lao PDR); Chapter III until Chapter VII (Provided the estimation methods for the sources of the emissions and sinks described in the 2006 IPPC Guidelines); Chapter VIII (provided the explanations on improvements plan and recalculation).

The Ministry of Agriculture and Environment, on behalf of the Lao PDR government, would like to express our appreciation to the steering committee, line ministries, development partners, national experts, and international organizations for their invaluable contribution. Also, thanks to the Global Environment Facility (GEF) and the United Nations Environment Program (UNEP) for their financial support and technical. Last, thanks to the Ministry of the Environment of Japan, especially the Mitsubishi UFJ Research and Consulting Ltd., Japan, for their technical support in developing the NIR report.

Lao PDR’s Greenhouse Gas Inventory 2020-2022

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Executive Summary of the National GHG Inventory Document of Lao PDR

E.S.1. Background Information on the GHG Inventory and Climate

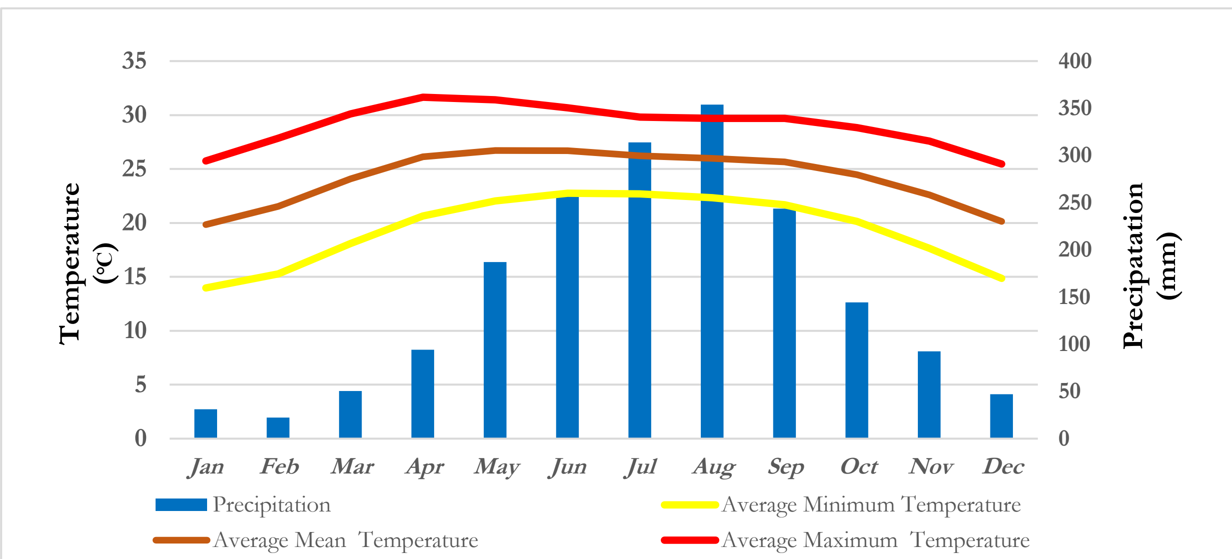
ES.1.1. Background Information on Climate Change in Lao PDR

Lao PDR is a landlocked country bordering China to the north, Vietnam to the east, Cambodia to the South, Thailand to the west, and Myanmar to the Northers. The country's total area is 236,800 km2, stretching 1,700 km from north to south and 100 to 400 from east to west. The altitude in the mountain area, rising over 1,000 meters above sea level with high humidity and mean annual precipitation between 1,500 to 2,000 mm, and in the mountain regions of the central and southern part of the country between 500-1000 meters with an average yearly rainfall of 2,500 to 3,500 mm[1]

There are two seasons in Lao PDR. The rainy season starts from May to mid-October, and the dry season begins between mid-October and April. In each part of the country, Lao PDR has a distinct temperature. For instance, In the northern, eastern mountainous, and the plateaus area, the average temperature is 20°C while the plain area is a higher temperature with an average between 25-27°C [2]

Considering on the country's altitude, Lao PDR can be divided into three different climatic zones.

1) The northern mountainous areas, above 1,000 meters in altitude, have a temperate and hilly sub-tropical climate with a mean rainfall between 1,500 and 2,000mm. These areas are quite dry and cooler compared to the rest of the country;
2) The central mountainous areas are tropical monsoonal climates with altitudes ranging from 500 to 1,000m. This area is experiencing a rise in temperature and has an average annual rainfall between 2,500 and 3,500 millimeters per year;
3) The lowland area has an average annual rainfall ranging from 1,500 to 2,000 millimeters. This area is located along the Mekong River and its tributaries, and it is residence for more than 50 % of the country's population.



[1] Work Bank and ADB (2021). Climate Risk Country Profile, Lao PDR.

[2] Work Bank and ADB (2021). Climate Risk Country Profile, Lao PDR.

Figure 1: Temperature and average mean precipitation [3]

From 2009 until 2018, the communities in Lao PDR have significantly faced climate change, escalating issues of impoverishment, poor health, and constrained access to facilities: schools, hospitals, education, markets, agriculture, culture, settlement, infrastructure, and tourism. Over the past decade, annual economic loss and damage from flooding and drought was $ 94 million in 2009, $ 200 million in 2011, $ 219 million in 2013, and $ 371.5 million in 2018, which was equivalent to 2.1% of the country's projected 2018 GDP (Figure 2)

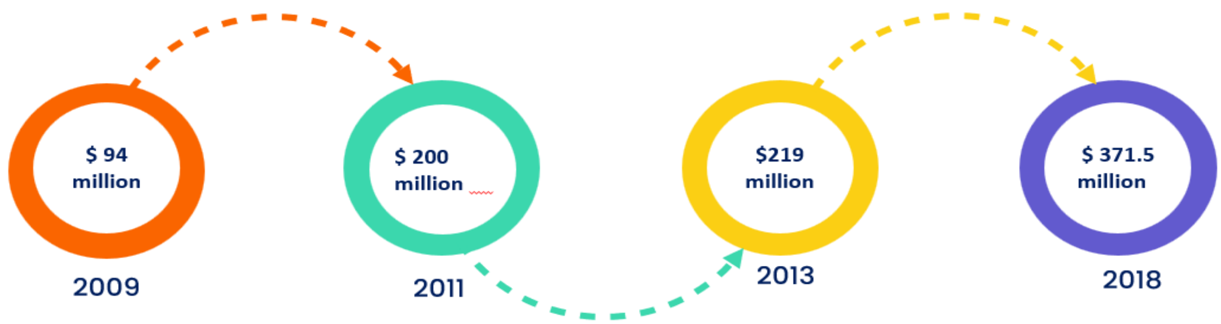


Figure 2: Annual economic loss and damage from flooding and drought since 2009-2018[4]

ES.1.2. Background Information on Greenhouse Gas Inventories

This National Inventory Report contains detailed information on Lao PDR's greenhouse gas (GHG) emissions and their removals from 2020 to 2022. The report structure conforms with the Modalities, Procedures, and Guidelines for the Transparency Framework for Action and Support Referred to in Article 13 of the Paris Agreement (MPGs, Decision 18/CMA.1 Annex).

The GHG estimation method was based on the 2006 IPCC Guidelines, developed by the Intergovernmental Panel on Climate Change (IPCC). The annual emission inventories from 2020 to 2022 are reported in the Common Reporting Table (CRT). This CRT report includes each year's emission data, activity data, and implied emission factors. The emission trends are provided for each greenhouse gas and for total greenhouse gas emissions in CO_2 equivalents.

The annual emission inventories for 2020 – 2022 are reported in the Common Reporting Table (CRT). Within this submission, separate CRTs are available at the Department of Climate Change, Ministry of Natural Resource and Environment, and (UNFCCC). The CRT spreadsheet encompasses data on emission, activity data, and applied emission factors for each year. Emission trends are given for each greenhouse gas and total greenhouse gas emissions in CO_2 equivalent. In addition, the CRT comprises trends in greenhouse gas emissions, a description of each emission category, planned improvements, and procedures for quality assurance and control.

[3] WBG Climate Change Knowledge Portal (CCKP, 2019). Climate Data: Historical: URL: https://climateknowledgeportal.worldbank.org/country/lao-pdr/climate-data-historical

[4] Lao PDR (2023). Implementation Plan for the Nationally Determined Contributions of Lao PDR

E.S.2. Summary of National Emission and Removal Trends (By gas)

The total GHG emission for 2022 in Lao PDR (Excl, LULUCF) was 38,844.04 Gg CO2 eq, in which the highest GHG emission was CO_2, accounting for 25,692.19 GgCO_2 eq or 66.14% and the lowest GHG emission were HFCs, accounting for 200.02 GgCO_2 eq or 0.51%. Since 2020, the amount of CO_2 has increased by 10.56 % compared to the emission in 2022 (Figure 03) and (Figure 04)

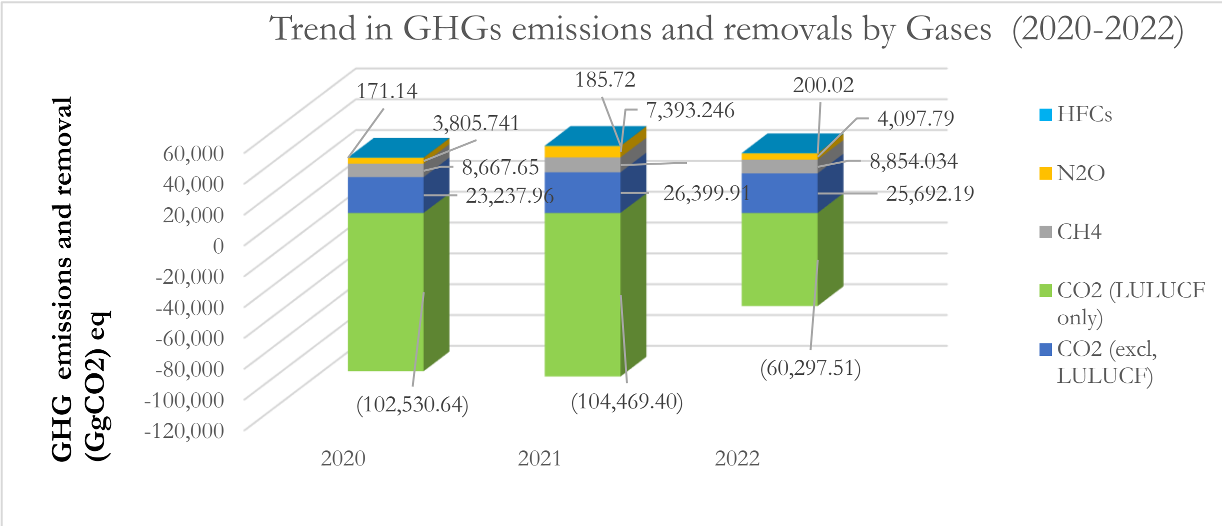


Figure 3: Trend in GHGs Emissions and Removals by Gases (Excl, LULUCF) from 2020 – 2022

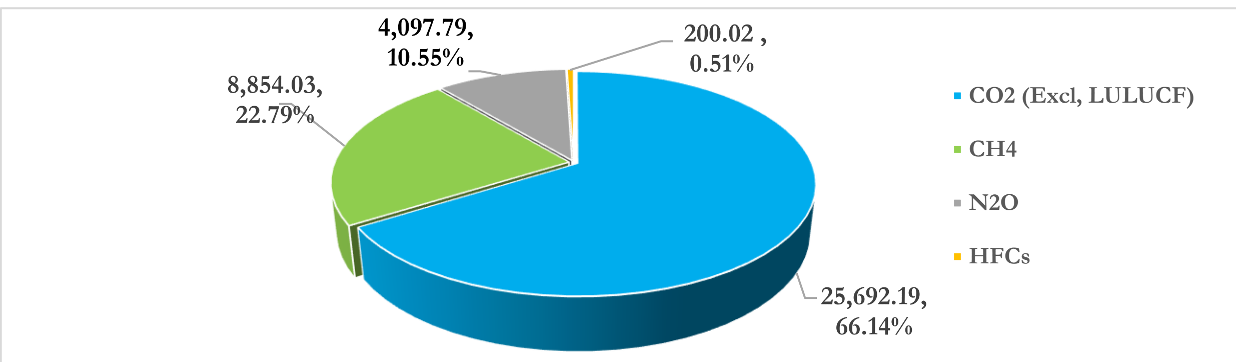


Figure 4: Share of GHGs Emissions and Removals by Gases (Excl, LULUCF) for 2022 in percent (%)

Table 1: Trends in GHG Emission and Removal by Gases, 2020 – 2022

Trends in GHG emission and Removal	2020	2021	2022
CO_2 (Exclu, LULUCF)	23,237.96	26,399.91	25,692.19
CO_2 (LULUCF only)	(102,530.64)	(104,469.40)	(60,297.51)
CH_4 (Excl, LULUCF)	8,667.65	8,736.52	8,854.03
CH_4 (Incl, LULUCF)	8,737.22	9,651.87	8,885.76
N_2O (Excl, LULUCF)	3,805.74	6,751.53	4,097.79
N_2O (Incl, LULUCF)	3,825.11	7,393.25	4,106.62
HFCs	171.14	185.72	200.02
Total (Excl, LULUCF)	35,882.49	42,073.67	38,844.04
Total (LULUCF only)	(102,530.64)	(104,469.40)	(60,297.51)
Total GHG Removals and Sinks	**(66,648.15)**	**(62,395.73)**	**(21,453.47)**

E.S.3. Overview of Source and Sink Category Emission Estimates and Trends by Sector

The total (Excl, LULUCF) GHG emissions in Lao PDR in 2020, 2021, and 2022 are 35,882.49 (Gg CO_2 eq), 42,073.67 (Gg CO_2 eq), and 38,844.04 (Gg CO_2 eq), respectively while the GHGs emissions and removals from the (LULUCF, Only) in 2020, 2021, and 2022 are (102,530.63) (Gg CO_2 eq), (104,469.39) (Gg CO_2 eq), and (60,297.51) (Gg CO_2 eq), respectively. The total GHGs emissions change from 2020 until 2022 has increased by 8.25% (Figure 5).

In 2022, the GHG emissions by sector present that the energy sector is the largest emission source, accounting for 21,688.98 GgCO_2eq or 55.84%, followed by the agriculture sector, accounting for 10,480.02 GgCO_2eq or 26.98%, the IPPU accounting for 5,226.55 GgCO_2eq or 13.46%, and the Waste sector accounting for 1,448.49 GgCO_2eq or 3.73% (Figure 6). The emission result also shows that Lao PDR is a net sink of (21,453.47) GgCO_2eq, which is derived by total removal from (LULUCF, Only) (60,297.51) Gg CO_2 eq and total (Excl, LULUCF) by 38,844.04 Gg CO_2 eq (Table 02).

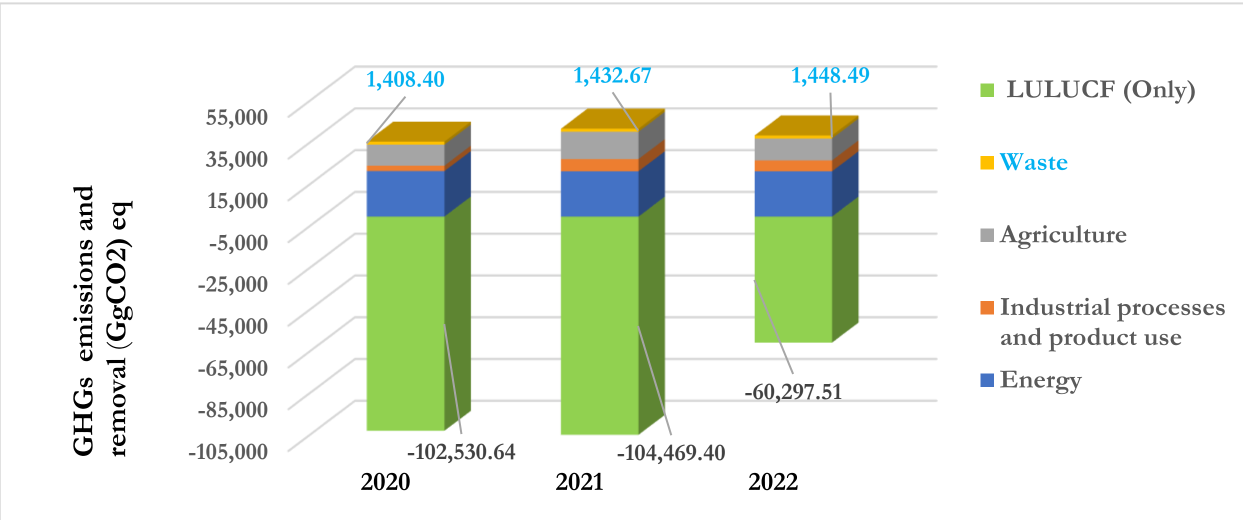


Figure 5: Trend in GHGs Emissions and Removals by Sector from 2020 – 2022

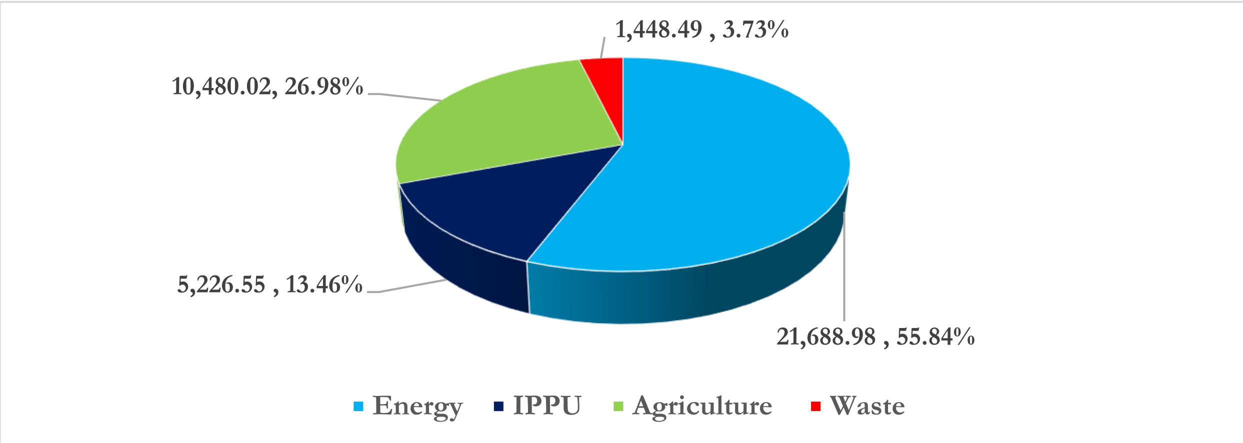


Figure 6: Share of GHGs Emissions and Removals (Excl, LULUCF) by Sector for 2022 in Percent (%)

Table 2: Trends in GHGs Emissions and Removals by Sectors for 2020 – 2022

Source Categories	2020	2021	2022
Energy	21,786.61	21,705.15	21,688.98
Industrial processes and product use	2,606.78	5,849.95	5,226.55
Agriculture	10,080.71	13,085.90	10,480.02
Waste	1,408.40	1,432.67	1,448.49
LULUCF (Only)	(102,530.64)	(104,469.40)	(60,297.51)
Total (Excl, LULUCF)	35,882.49	42,073.67	38,844.04
Total GHGs Removals and Sink	(66,648.14)	(62,395.72)	(21,453.47)

E.S.4. Brief Description of Key Categories

The Modalities, Procedures, and Guidelines for the Transparency Framework for Action and Support Referred to in Article 13 of the Paris Agreement (Decision 18/CMA. 1 Annex) require parties to identify key categories by implementing a key category analysis in compliance with the 2006 IPCC Guideline. The key category analyses were done for both data of fiscal year 2022 (The latest year of the inventory time series) and fiscal year 2020 (the start year). The result is presented below:

E.S.4.1. Key Categories Analysis

Key category analysis was conducted in a compliance with the 2006 IPCC Guidelines. The Approach 1, Level and Trend assessment has applied for all of the inventory categories. This included both including and excluding of the LULUCF sector. The analysis concluded that, in the case of including the LULUCF sector, there were 57 sources and sinks and 11 key categories for 2022 while excluding LULUCF sector were 48 source and sinks and 14 key categories for 2022.

Based on the Modalities, Procedures, and Guideline for the Transparency Framework for Action and Support Refereed to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex), all parties require to analysis key categories based on the 2006 IPCC Guidelines for analyzing a key category. The detailed is presented in (Table 3).

Table 3: Lao PDR Key Categories for 2022, Including the LULUCF sector

NO	A Code	B Category	C GHGs	AP1-L	AP1-T
#1	3.B.1.a	Forest land Remaining Forest land	CO_2	#1	#2
#2	3.B.2.b	Land Converted to Cropland	CO_2	#2	#1
#3	1.A.1	Energy Industries - Solid Fuels	CO_2	#3	#3
#4	3.B.1.b	Land Converted to Forest land	CO_2	#4	#6
#5	2.A.1	Cement production	CO_2	#5	#7
#6	3.B.6.b	Land Converted to Other land	CO_2	#6	#4
#7	3.A.1	Enteric Fermentation	CH_4	#7	#8
#8	3.D.1	Harvested Wood Products	CO_2	#8	#5
#9	3.C.4	Direct N_2O Emissions from managed soils	N_2O	#9	
#10	1.A.3.b	Road Transportation - Liquid Fuels	CO_2	#10	
#11	3.C.7	Rice cultivation	CH_4		
#12	3.A.2	Manure Management	CH_4		
#13	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2		
#14	4.D	Wastewater Treatment and Discharge	CH_4		
#15	3.B.2.a	Cropland Remaining Cropland	CO_2		#9
#16	3.C.5	Indirect N_2O Emissions from managed soils	N_2O		

#17	3.A.2	Manure Management	N_2O		
#18	1.A.4	Other Sectors - Biomass - solid	CH_4		
#19	4.A	Solid Waste Disposal	CH_4		
#20	1.B.1.a	Coal mining and handling	CH_4		
#21	3.B.5.b	Land Converted to Settlements	CO_2		
#22	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2		
#23	2.F.1	Refrigeration and Air Conditioning	HFCs		
#24	3.C.1	Burning	CH_4		
#25	1.A.4	Other Sectors - Liquid Fuels	CO_2		
#26	1.A.1	Energy Industries - Solid Fuels	N_2O		
#27	3.C.1	Burning	N_2O		
#28	3.C.6	Indirect N_2O Emissions from manure management	N_2O		
#29	1.A.4	Other Sectors - Biomass - solid	N_2O		
#30	4.D	Wastewater Treatment and Discharge	N_2O		
#31	1.A.3.b	Road Transportation - Liquid Fuels	N_2O		
#32	3.B.3.b	Land Converted to Grassland	CO_2		
#33	3.C.3	Urea application	CO_2		
#34	1.A.3.a	Civil Aviation - Liquid Fuels	CO_2		
#35	1.A.3.b	Road Transportation - Liquid Fuels	CH_4		
#36	2.A.2	Lime production	CO_2		
#37	1.A.1	Energy Industries - Solid Fuels	CH_4		
#38	2.C.1	Iron and Steel Production	CO_2		
#39	1.A.2	Manufacturing Industries and Construction - Solid Fuels	N_2O		
#40	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CH_4		
#41	1.A.2	Manufacturing Industries and Construction - Biomass - solid	N_2O		
#42	1.A.2	Manufacturing Industries and Construction - Biomass - solid	CH_4		
#43	3.B.4.b.ii	Land converted to Flooded Land	CO_2		
#44	1.A.1	Energy Industries - Biomass - solid	N_2O		
#45	3.C.2	Liming	CO_2		
#46	1.A.1	Energy Industries - Biomass - solid	CH_4		
#47	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	N_2O		
#48	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CH_4		
#49	1.A.3.e	Other Transportation - Liquid Fuels	CO_2		
#50	1.A.4	Other Sectors - Liquid Fuels	CH_4		
#51	4.C	Incineration and Open Burning of Waste	CO_2		
#52	2.D	Non-Energy Products from Fuels and Solvent Use	CO_2		
#53	1.A.4	Other Sectors - Liquid Fuels	N_2O		
#54	1.A.3.a	Civil Aviation - Liquid Fuels	N_2O		
#55	1.A.3.e	Other Transportation - Liquid Fuels	N_2O		
#56	1.A.3.a	Civil Aviation - Liquid Fuels	CH_4		
#57	1.A.3.e	Other Transportation - Liquid Fuels	CH_4		

Note1: Ap1-L: Approach 1-Level Assessment, Ap1-T: Approach 1-Trend Assessment
Note2: Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

Table 4 : Lao PDR Key Categories for 2020, Including the LULUCF Sector

No	A Code	B Category	C GHGs	AP1-L
#1	3.B.1.a	Forest land Remaining Forest land	CO_2	#1
#2	1.A.1	Energy Industries - Solid Fuels	CO_2	#2
#3	3.B.1.b	Land Converted to Forest land	CO_2	#3
#4	3.A.1	Enteric Fermentation	CH_4	#4
#5	1.A.3.b	Road Transportation - Liquid Fuels	CO_2	#5
#6	2.A.1	Cement production	CO_2	#6
#7	3.C.4	Direct N_2O Emissions from managed soils	N_2O	#7
#8	3.C.7	Rice cultivation	CH_4	#8

#9	3.B.6.b	Land Converted to Other land	CO_2	#9
#10	3.A.2	Manure Management	CH_4	
#11	4.D	Wastewater Treatment and Discharge	CH_4	
#12	3.B.2.b	Land Converted to Cropland	CO_2	
#13	3.C.5	Indirect N_2O Emissions from managed soils	N_2O	
#14	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	
#15	3.A.2	Manure Management	N_2O	
#16	1.A.4	Other Sectors - Biomass - solid	CH_4	
#17	4.A	Solid Waste Disposal	CH_4	
#18	3.C.1	Burning	CH_4	
#19	1.B.1.a	Coal mining and handling	CH_4	
#20	3.C.1	Burning	N_2O	
#21	2.F.1	Refrigeration and Air Conditioning	HFCs	
#22	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	
#23	3.D.1	Harvested Wood Products	CO_2	
#24	1.A.4	Other Sectors - Liquid Fuels	CO_2	
#25	1.A.1	Energy Industries - Solid Fuels	N_2O	
#26	3.C.6	Indirect N_2O Emissions from manure management	N_2O	
#27	1.A.4	Other Sectors - Biomass - solid	N_2O	
#28	4.D	Wastewater Treatment and Discharge	N_2O	
#29	1.A.3.b	Road Transportation - Liquid Fuels	N_2O	
#30	3.B.2.a	Cropland Remaining Cropland	CO_2	
#31	3.C.3	Urea application	CO_2	
#32	2.C.1	Iron and Steel Production	CO_2	
#33	1.A.3.a	Civil Aviation - Liquid Fuels	CO_2	
#34	1.A.3.b	Road Transportation - Liquid Fuels	CH_4	
#35	2.A.2	Lime production	CO_2	
#36	1.A.1	Energy Industries - Solid Fuels	CH_4	
#37	1.A.2	Manufacturing Industries and Construction - Biomass - solid	N_2O	
#38	1.A.2	Manufacturing Industries and Construction - Solid Fuels	N_2O	
#39	1.A.2	Manufacturing Industries and Construction - Biomass - solid	CH_4	
#40	3.C.2	Liming	CO_2	
#41	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CH_4	
#42	1.A.1	Energy Industries - Biomass - solid	N_2O	
#43	1.A.1	Energy Industries - Biomass - solid	CH_4	
#44	2.D	Non-Energy Products from Fuels and Solvent Use	CO_2	
#45	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	N_2O	
#46	3.B.3.b	Land Converted to Grassland	CO_2	
#47	1.A.3.e	Other Transportation - Liquid Fuels	CO_2	
#48	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CH_4	
#49	1.A.4	Other Sectors - Liquid Fuels	CH_4	
#50	1.A.4	Other Sectors - Liquid Fuels	N_2O	
#51	4.C	Incineration and Open Burning of Waste	CO_2	
#52	1.A.3.a	Civil Aviation - Liquid Fuels	N_2O	
#53	1.A.3.e	Other Transportation - Liquid Fuels	N_2O	
#54	1.A.3.a	Civil Aviation - Liquid Fuels	CH_4	
#55	1.A.3.e	Other Transportation - Liquid Fuels	CH_4	

Note1: Ap1-L: Approach 1-Level Assessment
Note2: Figures recorded in the Level and Trend columns indicate the ranking of individual level assessments.

Table 5: Lao PDR Key Categories for 2022, Excluding the LULUCF Sector

No	A Code	B Category	C GHGs	AP1- L	AP1- T
#1	1.A.1	Energy Industries - Solid Fuels	CO_2	#1	#2
#2	2.A.1	Cement production	CO_2	#2	#1

#3	3.A.1	Enteric Fermentation	CH_4	#3	
#4	3.C.4	Direct N_2O Emissions from managed soils	N_2O	#4	#6
#5	1.A.3.b	Road Transportation - Liquid Fuels	CO_2	#5	#7
#6	3.C.7	Rice cultivation	CH_4	#6	#8
#7	3.A.2	Manure Management	CH_4	#7	
#8	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	#8	
#9	4.D	Wastewater Treatment and Discharge	CH_4	#9	#9
#10	3.C.5	Indirect N_2O Emissions from managed soils	N_2O	#10	
#11	3.A.2	Manure Management	N_2O	#11	
#12	1.A.4	Other Sectors - Biomass - solid	CH_4		
#13	4.A	Solid Waste Disposal	CH_4		
#14	1.B.1.a	Coal mining and handling	CH_4		
#15	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2		#3
#16	2.F.1	Refrigeration and Air Conditioning	HFCs		
#17	3.C.1	Burning	CH_4		#4
#18	1.A.4	Other Sectors - Liquid Fuels	CO_2		
#19	1.A.1	Energy Industries - Solid Fuels	N_2O		
#20	3.C.1	Burning	N_2O		#5
#21	3.C.6	Indirect N_2O Emissions from manure management	N_2O		
#22	1.A.4	Other Sectors - Biomass - solid	N_2O		
#23	4.D	Wastewater Treatment and Discharge	N_2O		
#24	1.A.3.b	Road Transportation - Liquid Fuels	N_2O		
#25	3.C.3	Urea application	CO_2		
#26	1.A.3.a	Civil Aviation - Liquid Fuels	CO_2		
#27	1.A.3.b	Road Transportation - Liquid Fuels	CH_4		
#28	2.A.2	Lime production	CO_2		
#29	1.A.1	Energy Industries - Solid Fuels	CH_4		
#30	2.C.1	Iron and Steel Production	CO_2		
#31	1.A.2	Manufacturing Industries and Construction - Solid Fuels	N_2O		
#32	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CH_4		
#33	1.A.2	Manufacturing Industries and Construction - Biomass - solid	N_2O		
#34	1.A.2	Manufacturing Industries and Construction - Biomass - solid	CH_4		
#35	1.A.1	Energy Industries - Biomass - solid	N_2O		
#36	3.C.2	Liming	CO_2		
#37	1.A.1	Energy Industries - Biomass - solid	CH_4		
#38	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	N_2O		
#39	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CH_4		
#40	1.A.3.e	Other Transportation - Liquid Fuels	CO_2		
#41	1.A.4	Other Sectors - Liquid Fuels	CH_4		
#42	4.C	Incineration and Open Burning of Waste	CO_2		
#43	2.D	Non-Energy Products from Fuels and Solvent Use	CO_2		
#44	1.A.4	Other Sectors - Liquid Fuels	N_2O		
#45	1.A.3.a	Civil Aviation - Liquid Fuels	N_2O		
#46	1.A.3.e	Other Transportation - Liquid Fuels	N_2O		
#47	1.A.3.a	Civil Aviation - Liquid Fuels	CH_4		
#48	1.A.3.e	Other Transportation - Liquid Fuels	CH_4		

Note1: Ap1-L: Approach 1-Level Assessment, Ap1-T: Approach 1-Trend Assessment,
Note2: Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

Table 6: Lao PDR Key Categories for 2020, Excluding the LULUCF Sector

No	A Code	B Category	C GHGs	AP1-L
#1	1.A.1	Energy Industries - Solid Fuels	CO_2	#1
#2	3.A.1	Enteric Fermentation	CH_4	#2
#3	1.A.3.b	Road Transportation - Liquid Fuels	CO_2	#3

#4	2.A.1	Cement production	CO_2	#4
#5	3.C.4	Direct N_2O Emissions from managed soils	N_2O	#5
#6	3.C.7	Rice cultivation	CH_4	#6
#7	3.A.2	Manure Management	CH_4	#7
#8	4.D	Wastewater Treatment and Discharge	CH_4	#8
#9	3.C.5	Indirect N_2O Emissions from managed soils	N_2O	#9
#10	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	#10
#11	3.A.2	Manure Management	N_2O	#11
#12	1.A.4	Other Sectors - Biomass - solid	CH_4	#12
#13	4.A	Solid Waste Disposal	CH_4	
#14	3.C.1	Burning	CH_4	
#15	1.B.1.a	Coal mining and handling	CH_4	
#16	3.C.1	Burning	N_2O	
#17	2.F.1	Refrigeration and Air Conditioning	HFCs	
#18	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	
#19	1.A.4	Other Sectors - Liquid Fuels	CO_2	
#20	1.A.1	Energy Industries - Solid Fuels	N_2O	
#21	3.C.6	Indirect N_2O Emissions from manure management	N_2O	
#22	1.A.4	Other Sectors - Biomass - solid	N_2O	
#23	4.D	Wastewater Treatment and Discharge	N_2O	
#24	1.A.3.b	Road Transportation - Liquid Fuels	N_2O	
#25	3.C.3	Urea application	CO_2	
#26	2.C.1	Iron and Steel Production	CO_2	
#27	1.A.3.a	Civil Aviation - Liquid Fuels	CO_2	
#28	1.A.3.b	Road Transportation - Liquid Fuels	CH_4	
#29	2.A.2	Lime production	CO_2	
#30	1.A.1	Energy Industries - Solid Fuels	CH_4	
#31	1.A.2	Manufacturing Industries and Construction - Biomass - solid	N_2O	
#32	1.A.2	Manufacturing Industries and Construction - Solid Fuels	N_2O	
#33	1.A.2	Manufacturing Industries and Construction - Biomass - solid	CH_4	
#34	3.C.2	Liming	CO_2	
#35	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CH_4	
#36	1.A.1	Energy Industries - Biomass - solid	N_2O	
#37	1.A.1	Energy Industries - Biomass - solid	CH_4	
#38	2.D	Non-Energy Products from Fuels and Solvent Use	CO_2	
#39	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	N_2O	
#40	1.A.3.e	Other Transportation - Liquid Fuels	CO_2	
#41	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CH_4	
#42	1.A.4	Other Sectors - Liquid Fuels	CH_4	
#43	1.A.4	Other Sectors - Liquid Fuels	N_2O	
#44	4.C	Incineration and Open Burning of Waste	CO_2	
#45	1.A.3.a	Civil Aviation - Liquid Fuels	N_2O	
#46	1.A.3.e	Other Transportation - Liquid Fuels	N_2O	
#47	1.A.3.a	Civil Aviation - Liquid Fuels	CH_4	
#48	1.A.3.e	Other Transportation - Liquid Fuels	CH_4	

Note1: Ap1-L: Approach 1-Level Assessment

Note2: Figures recorded in the Level and Trend columns indicate the ranking of individual level assessments.

E.S.4.2. Level Assessment

Level assessment relevant to the key categories analysis by calibrating each category's emission and removal proportion to the total emissions and removals. The calibrated proportion values are added from the category that accounts for the largest proportion until the sum reaches 95% for approach 1. Based on the Approach 1 level assessment of emission and removal found that the key categories, including LULUCF, were 10 sources and 11 sources excluding LULUCF for 2022, while the Approach 1 level assessment of emission and removal for 2020, including LULUCF, were 9 sources of the key categories and excluding LULUCF were 12 of the key categories. The details are presented in (Table 7).

Table 7: Result of Approach 1 Level Assessment for 2022

No	A Code	B Category	C GHGs	F Current Year Estimate (Gg CO_2 Eq)	H AP1-L	I Ap1-L Contrib. [%]	Cumulative contrib. [%]
Including LULUCF							
#1	3.B.1.a	Forest land Remaining Forest land	CO_2	87,629.140	0.479	47.9%	47.9%
#2	3.B.2.b	Land Converted to Cropland	CO_2	36,692.976	0.200	20.0%	67.9%
#3	1.A.1	Energy Industries - Solid Fuels	CO_2	16,817.409	0.092	9.2%	77.1%
#4	3.B.1.b	Land Converted to Forest land	CO_2	11,978.394	0.065	6.5%	83.6%
#5	2.A.1	Cement production	CO_2	5,015.338	0.027	2.7%	86.3%
#6	3.B.6.b	Land Converted to Other land	CO_2	4,157.453	0.023	2.3%	88.6%
#7	3.A.1	Enteric Fermentation	CH_4	3,678.043	0.020	2.0%	90.6%
#8	3.D.1	Harvested Wood Products	CO_2	2,685.679	0.015	1.5%	92.1%
#9	3.C.4	Direct N_2O Emissions from managed soils	N_2O	2,575.316	0.014	1.4%	93.5%
#10	1.A.3.b	Road Transportation - Liquid Fuels	CO_2	2,536.567	0.014	1.4%	94.9%
Excluding LULUCF							
#1	1.A.1	Energy Industries - Solid Fuels	CO_2	16817.409	0.432495	43.2%	43.2%
#2	2.A.1	Cement production	CO_2	5015.338195	0.12898	12.9%	56.1%
#3	3.A.1	Enteric Fermentation	CH_4	3678.043208	0.094589	9.5%	65.6%
#4	3.C.4	Direct N_2O Emissions from managed soils	N_2O	2575.316047	0.06623	6.6%	72.2%
#5	1.A.3.b	Road Transportation - Liquid Fuels	CO_2	2536.5667	0.065233	6.5%	78.8%
#6	3.C.7	Rice cultivation	CH_4	1754.790078	0.045128	4.5%	83.3%
#7	3.A.2	Manure Management	CH_4	1036.333616	0.026652	2.7%	85.9%
#8	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	1008.2815	0.02593	2.6%	88.5%
#9	4.D	Wastewater Treatment and Discharge	CH_4	980.6830099	0.02522	2.5%	91.0%
#10	3.C.5	Indirect N_2O Emissions from managed soils	N_2O	699.1122221	0.017979	1.8%	92.8%
#11	3.A.2	Manure Management	N_2O	498.6798538	0.012825	1.3%	94.1%

Table 8 : Result of Approach 1 Level Assessment for 2020

No	A Code	B Category	C GHGs	F Current Year Estimate (Gg CO_2Eq)	H AP1-L	I Ap1-L Contrib. [%]	Cumulative contrib. [%]
Including LULUCF							
#1	3.B.1.a	Forest land Remaining Forest land	CO_2	88,642.59508	0.63	63.0%	63.0%
#2	1.A.1	Energy Industries - Solid Fuels	CO_2	17,623.08600	0.13	12.5%	75.5%
#3	3.B.1.b	Land Converted to Forest land	CO_2	13,872.88331	0.10	9.9%	85.4%
#4	3.A.1	Enteric Fermentation	CH_4	3,464.58823	0.02	2.5%	87.9%
#5	1.A.3.b	Road Transportation - Liquid Fuels	CO_2	2,438.26030	0.02	1.7%	89.6%
#6	2.A.1	Cement production	CO_2	2,418.59499	0.02	1.7%	91.3%
#7	3.C.4	Direct N_2O Emissions from managed soils	N_2O	2,216.21137	0.02	1.6%	92.9%
#8	3.C.7	Rice cultivation	CH_4	1,689.38722	0.01	1.2%	94.1%
#9	3.B.6.b	Land Converted to Other land	CO_2	1,040.69774	0.01	0.7%	94.8%
Excluding LULUCF							
1	1.A.1	Energy Industries - Solid Fuels	CO_2	17623.086	0.490	49.0%	49.0%
2	3.A.1	Enteric Fermentation	CH_4	3464.588232	0.096	9.6%	58.6%
3	1.A.3.b	Road Transportation - Liquid Fuels	CO_2	2438.2603	0.068	6.8%	65.4%
4	2.A.1	Cement production	CO_2	2418.594991	0.067	6.7%	72.1%
5	3.C.4	Direct N_2O Emissions from managed soils	N_2O	2216.211373	0.062	6.2%	78.3%
6	3.C.7	Rice cultivation	CH_4	1689.387219	0.047	4.7%	83.0%
7	3.A.2	Manure Management	CH_4	1004.912067	0.028	2.8%	85.8%
8	4.D	Wastewater Treatment and Discharge	CH_4	972.7312923	0.027	2.7%	88.5%
9	3.C.5	Indirect N_2O Emissions from managed soils	N_2O	613.6490714	0.017	1.7%	90.2%

10	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	481.9747	0.013	1.3%	91.5%
11	3.A.2	Manure Management	N_2O	473.4860445	0.013	1.3%	92.8%
12	1.A.4	Other Sectors - Biomass - solid	CH_4	457.993284	0.013	1.3%	94.1%

E.S.4.3. Trend Assessment

The purpose of the trend assessment is to identify categories that may not be large enough to be identified by level assessment. The category trend refers to the variation in the source or sink category or removal over time, computed by subtracting the base year (0) estimate for source or sink category x from the latest inventory year (year t) estimate and dividing by the absolute value of the base year estimate.

The total trends refer to the variation in the total inventory emission or removals over time, calibrated by subtraction of the base year (0) estimate for the total inventory from the latest year (year t) and diving by the absolute value of the base year estimate. In Lao PDR, the trend assessment is computed from 2020 until 2022, which is the base year of Lao PDR. Equation 4.2, Page 4.15, and Equation 4.3, Page 4.16, 2006 IPCC Guidelines, Chapter 4, Volume 1 are applied to estimate the trend of the GHG emission source and sink
Approach 1 trend assessment of emission and removal for 2022 identified nine (9) subcategories as the key categories (including LULUCF) and nine (9) categories (excluding LULUCF). More details are presented in (Table **9)** below:

Table 9 : Result of Approach 1 Trend Assessment for 2022

	A code	B Category	C CHGs	D FY 2020 Estimate [Gg- CO_2 eq.]	F Current Year Estimate [Gg- CO_2 eq.]	J AP1-T	K AP1-T Contrib. [%]	Cumulative Contrib. [%]
Including LULUCF								
#1	3.B.2.b	Land Converted to Cropland	CO_2	972.094	36,692.976	0.266	43.0%	43.0%
#2	3.B.1.a	Forest land Remaining Forest land	CO_2	88642.595	7,629.140	0.195	31.6%	74.6%
#3	1.A.1	Energy Industries - Solid Fuels	CO_2	17623.086	6,817.409	0.046	7.4%	82.0%
#4	3.B.6.b	Land Converted to Other land	CO_2	1040.698	4,157.453	0.020	3.2%	85.2%
#5	3.D.1	Harvested Wood Products	CO_2	141.274	2,685.679	0.018	3.0%	88.2%
#6	3.B.1.b	Land Converted to Forest land	CO_2	13872.883	11,978.394	0.018	2.9%	91.2%
#7	2.A.1	Cement production	CO_2	2418.595	5,015.338	0.013	2.1%	93.2%
#8	3.A.1	Enteric Fermentation	CH_4	3464.588	3,678.043	0.006	1.0%	94.3%
Excluding LULUCF								
#1	2.A.1	Cement production	CO_2	2418.594991	5015.338195	0.067	37.8%	37.8%
#2	1.A.1	Energy Industries - Solid Fuels	CO_2	17623.086	16817.409	0.062	35.2%	73.0%
#3	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	481.9747	1008.2815	0.014	7.7%	80.7%
#4	3.C.1	Burning	CH_4	378.6037313	137.720866	0.008	4.3%	85.0%
#5	3.C.1	Burning	N_2O	256.12735	63.85864948	0.006	3.4%	88.4%
#6	3.C.4	Direct N_2O Emissions from managed soils	N_2O	2216.211373	2575.316047	0.005	2.8%	91.2%
#7	1.A.3.b	Road Transportation - Liquid Fuels	CO_2	2438.2603	2536.5667	0.003	1.6%	92.7%
#8	3.C.7	Rice cultivation	CH_4	1689.387219	1754.790078	0.002	1.1%	93.9%
#9	4.D	Wastewater Treatment and Discharge	CH_4	972.7312923	980.6830099	0.002	1.1%	95.0%

Table 10: Data used for the Key Category Analysis for 2022

A Code	B Category	C CHGs	E Absolute value of FY 2020 Estimate [Gg- CO_2 eq.]	G Absolute value of Current Year Estimate [Gg- CO_2 eq.]	H AP1-L	I Ap1-L Contrib. [%]	J AP1-T	K AP1-T Contrib. [%]
1.A.1	Energy Industries - Solid Fuels	CO_2	17623.086	16817.409	0.092	77.1%	0.046	7.4%
1.A.1	Energy Industries - Solid Fuels	N_2O	69.358	66.187	0.000	99.8%	0.000	0.0%
1.A.1	Energy Industries - Solid Fuels	CH_4	4.886	4.662	0.000	100.0%	0.000	0.0%
1.A.1	Energy Industries - Biomass - solid	N_2O	0.954	0.602	0.000	100.0%	0.000	0.0%
1.A.1	Energy Industries - Biomass - solid	CH_4	0.756	0.477	0.000	100.0%	0.000	0.0%
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	481.975	1008.282	0.006	97.0%	0.003	0.4%
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	157.215	200.619	0.001	99.5%	0.000	0.0%
1.A.2	Manufacturing Industries and Construction - Solid Fuels	N_2O	1.929	4.056	0.000	100.0%	0.000	0.0%
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CH_4	1.359	2.857	0.000	100.0%	0.000	0.0%
1.A.2	Manufacturing Industries and Construction - Biomass - solid	N_2O	2.413	2.383	0.000	100.0%	0.000	0.0%
1.A.2	Manufacturing Industries and Construction - Biomass - solid	CH_4	1.912	1.888	0.000	100.0%	0.000	0.0%
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	N_2O	0.334	0.426	0.000	100.0%	0.000	0.0%
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CH_4	0.176	0.225	0.000	100.0%	0.000	0.0%
1.A.3.a	Civil Aviation - Liquid Fuels	CO_2	9.581	9.939	0.000	100.0%	0.000	0.0%
1.A.3.a	Civil Aviation - Liquid Fuels	N_2O	0.071	0.074	0.000	100.0%	0.000	0.0%
1.A.3.a	Civil Aviation - Liquid Fuels	CH_4	0.002	0.002	0.000	100.0%	0.000	0.0%
1.A.3.b	Road Transportation - Liquid Fuels	CO_2	2438.260	2536.567	0.014	94.9%	0.005	0.8%
1.A.3.b	Road Transportation - Liquid Fuels	N_2O	33.153	34.490	0.000	100.0%	0.000	0.0%
1.A.3.b	Road Transportation - Liquid Fuels	CH_4	9.033	9.397	0.000	100.0%	0.000	0.0%
1.A.3.e	Other Transportation - Liquid Fuels	CO_2	0.216	0.216	0.000	100.0%	0.000	0.0%
1.A.3.e	Other Transportation - Liquid Fuels	N_2O	0.022	0.022	0.000	100.0%	0.000	0.0%
1.A.3.e	Other Transportation - Liquid Fuels	CH_4	0.000	0.000	0.000	100%	0.000	0.0%
1.A.4	Other Sectors - Biomass - solid	CH_4	457.993	449.649	0.002	98.8%	0.001	0.2%
1.A.4	Other Sectors - Liquid Fuels	CO_2	78.365	78.617	0.000	99.8%	0.000	0.0%
1.A.4	Other Sectors - Biomass - solid	N_2O	55.087	54.094	0.000	99.9%	0.000	0.0%
1.A.4	Other Sectors - Liquid Fuels	CH_4	0.173	0.174	0.000	100.0%	0.000	0.0%
1.A.4	Other Sectors - Liquid Fuels	N_2O	0.116	0.116	0.000	100.0%	0.000	0.0%
1.B.1.a	Coal mining and handling	CH_4	358.183	405.551	0.002	99.3%	0.000	0.1%
2.A.1	Cement production	CO_2	2418.595	5015.338	0.027	86.3%	0.013	2.1%
2.A.2	Lime production	CO_2	5.754	6.863	0.000	100.0%	0.000	0.0%
2.C.1	Iron and Steel Production	CO_2	10.762	4.161	0.000	100.0%	0.000	0.0%
2.D	Non-Energy Products from Fuels and Solvent Use	CO_2	0.528	0.161	0.000	100.0%	0.000	0.0%
2.F.1	Refrigeration and Air Conditioning	HFCs	171.143	200.022	0.001	99.7%	0.000	0.0%
3.A.1	Enteric Fermentation	CH_4	3464.588	3678.043	0.020	90.6%	0.006	1.0%
3.A.2	Manure Management	CH_4	1004.912	1036.334	0.006	96.4%	0.002	0.3%

3.A.2	Manure Management	N_2O	473.486	498.680	0.003	98.6%	0.001	0.1%
3.B.1.a	Forest land Remaining Forest land	CO_2	88642.595	87629.140	0.479	47.9%	0.195	31.6%
3.B.1.b	Land Converted to Forest land	CO_2	13872.883	11978.394	0.065	83.6%	0.018	2.9%
3.B.2.a	Cropland Remaining Cropland	CO_2	31.204	765.494	0.004	97.9%	0.006	0.9%
3.B.2.b	Land Converted to Cropland	CO_2	972.094	36692.976	0.200	67.9%	0.266	43.0%
3.B.3.b	Land Converted to Grassland	CO_2	0.225	20.242	0.000	100.0%	0.000	0.0%
3.B.4.b.ii	Land converted to Flooded Land	CO_2	0.000	1.302	0.000	100.0%	0.000	0.0%
3.B.5.b	Land Converted to Settlements	CO_2	0.000	317.672	0.002	99.4%	0.002	0.4%
3.B.6.b	Land Converted to Other land	CO_2	1040.698	4157.453	0.023	88.6%	0.020	3.2%
3.C.1	Burning	CH_4	378.604	137.721	0.001	99.7%	0.003	0.4%
3.C.1	Burning	N_2O	256.127	63.859	0.000	99.8%	0.002	0.3%
3.C.2	Liming	CO_2	1.662	0.535	0.000	100.0%	0.000	0.0%
3.C.3	Urea application	CO_2	11.881	13.317	0.000	100.0%	0.000	0.0%
3.C.4	Direct N_2O Emissions from managed soils	N_2O	2216.211	2575.316	0.014	93.5%	0.003	0.4%
3.C.5	Indirect N_2O Emissions from managed soils	N_2O	613.649	699.112	0.004	98.3%	0.001	0.1%
3.C.6	Indirect N_2O Emissions from manure management	N_2O	59.139	62.883	0.000	99.9%	0.000	0.0%
3.C.7	Rice cultivation	CH_4	1689.387	1754.790	0.010	95.8%	0.003	0.5%
3.D.1	Harvested Wood Products	CO_2	141.274	2685.679	0.015	92.1%	0.018	3.0%
4.A	Solid Waste Disposal	CH_4	392.523	423.310	0.002	99.0%	0.001	0.1%
4.C	Incineration and Open Burning of Waste	CO_2	0.080	0.170	0.000	100.0%	0.000	0.0%
4.D	Wastewater Treatment and Discharge	CH_4	972.731	980.683	0.005	97.5%	0.002	0.4%
4.D	Wastewater Treatment and Discharge	N_2O	43.061	44.323	0.000	99.9%	0.000	0.0%

Table 11 : Data used for the Key Category Analysis for 2020

A code	B Category	C CHGs	E Absolute value of FY 2020 Estimate [Gg-CO2eq.]	H AP1-L	I Ap1-L Contrib. [%]
1.A.1	Energy Industries - Solid Fuels	CO_2	17623.086	0.125	12.5%
1.A.1	Energy Industries - Solid Fuels	N_2O	69.358	0.000	0.0%
1.A.1	Energy Industries - Solid Fuels	CH_4	4.886	0.000	0.0%
1.A.1	Energy Industries - Biomass - solid	N_2O	0.954	0.000	0.0%
1.A.1	Energy Industries - Biomass - solid	CH_4	0.756	0.000	0.0%
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	481.975	0.003	0.3%
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	157.215	0.001	0.1%
1.A.2	Manufacturing Industries and Construction - Biomass - solid	N_2O	2.413	0.000	0.0%
1.A.2	Manufacturing Industries and Construction - Solid Fuels	N_2O	1.929	0.000	0.0%
1.A.2	Manufacturing Industries and Construction - Biomass - solid	CH_4	1.912	0.000	0.0%
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CH_4	1.359	0.000	0.0%
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	N_2O	0.334	0.000	0.0%
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CH_4	0.176	0.000	0.0%
1.A.3.a	Civil Aviation - Liquid Fuels	CO_2	9.581	0.000	0.0%
1.A.3.a	Civil Aviation - Liquid Fuels	N_2O	0.071	0.000	0.0%
1.A.3.a	Civil Aviation - Liquid Fuels	CH_4	0.002	0.000	0.0%
1.A.3.b	Road Transportation - Liquid Fuels	CO_2	2438.260	0.017	1.7%
1.A.3.b	Road Transportation - Liquid Fuels	N_2O	33.153	0.000	0.0%
1.A.3.b	Road Transportation - Liquid Fuels	CH_4	9.033	0.000	0.0%
1.A.3.e	Other Transportation - Liquid Fuels	CO_2	0.216	0.000	0.0%
1.A.3.e	Other Transportation - Liquid Fuels	N_2O	0.022	0.000	0.0%
1.A.3.e	Other Transportation - Liquid Fuels	CH_4	0.000	0.000	0.0%
1.A.4	Other Sectors - Biomass - solid	CH_4	457.993	0.003	0.3%

1.A.4	Other Sectors - Liquid Fuels	CO_2	78.365	0.001	0.1%
1.A.4	Other Sectors - Biomass - solid	N_2O	55.087	0.000	0.0%
1.A.4	Other Sectors - Liquid Fuels	CH_4	0.173	0.000	0.0%
1.A.4	Other Sectors - Liquid Fuels	N_2O	0.116	0.000	0.0%
1.B.1.a	Coal mining and handling	CH_4	358.183	0.003	0.3%
2.A.1	Cement production	CO_2	2418.595	0.017	1.7%
2.A.2	Lime production	CO_2	5.754	0.000	0.0%
2.C.1	Iron and Steel Production	CO_2	10.762	0.000	0.0%
2.D	Non-Energy Products from Fuels and Solvent Use	CO_2	0.528	0.000	0.0%
2.F.1	Refrigeration and Air Conditioning	HFCs	171.143	0.001	0.1%
3.A.1	Enteric Fermentation	CH_4	3464.588	0.025	2.5%
3.A.2	Manure Management	CH_4	1004.912	0.007	0.7%
3.A.2	Manure Management	N_2O	473.486	0.003	0.3%
3.B.1.a	Forest land Remaining Forest land	CO_2	88642.595	0.630	63.0%
3.B.1.b	Land Converted to Forest land	CO_2	13872.883	0.099	9.9%
3.B.2.a	Cropland Remaining Cropland	CO_2	31.204	0.000	0.0%
3.B.2.b	Land Converted to Cropland	CO_2	972.094	0.007	0.7%
3.B.3.b	Land Converted to Grassland	CO_2	0.225	0.000	0.0%
3.B.4.b.ii	Land converted to Flooded Land	CO_2	0.000	0.000	0.0%
3.B.5.b	Land Converted to Settlements	CO_2	0.000	0.000	0.0%
3.B.6.b	Land Converted to Other land	CO_2	1040.698	0.007	0.7%
3.C.1	Burning	CH_4	378.604	0.003	0.3%
3.C.1	Burning	N_2O	256.127	0.002	0.2%
3.C.2	Liming	CO_2	1.662	0.000	0.0%
3.C.3	Urea application	CO_2	11.881	0.000	0.0%
3.C.4	Direct N_2O Emissions from managed soils	N_2O	2216.211	0.016	1.6%
3.C.5	Indirect N_2O Emissions from managed soils	N_2O	613.649	0.004	0.4%
3.C.6	Indirect N_2O Emissions from manure management	N_2O	59.139	0.000	0.0%
3.C.7	Rice cultivation	CH_4	1689.387	0.012	1.2%
3.D.1	Harvested Wood Products	CO_2	141.274	0.001	0.1%
4.A	Solid Waste Disposal	CH_4	392.523	0.003	0.3%
4.C	Incineration and Open Burning of Waste	CO_2	0.080	0.000	0.0%
4.D	Wastewater Treatment and Discharge	CH_4	972.731	0.007	0.7%
4.D	Wastewater Treatment and Discharge	N_2O	43.061	0.000	0.0%

E.S.5. Improvement Introduced

The more detail of NIR improvement is provided in Chapter VIII, Page 122

CHAPTER I: NATIONAL CIRCUMSTANCE AND INSITUTION ARRANGEMENTS

1.1. Background Information on Lao PDR Greenhouse Gas Inventory and Climate Change

This report is Lao PDR National Inventory Report (NIR) 2024 for submission to the United Nations Framework Convention on Climate change (UNFCC). This National Inventory Report contains detailed information on Lao PDR's greenhouse gas (GHG) emissions and their removals from 2020 to 2022. The report structure conforms with the Modalities, Procedures, and Guidelines for the Transparency Framework for Action and Support Referred to in Article 13 of the Paris Agreement (MPGs, Decision 18/CMA.1 Annex).

The GHG estimation method was based on the 2006 IPCC Guidelines, developed by the Intergovernmental Panel on Climate Change (IPCC), and the annual emission inventories for the years from 2020 to 2022 are reported in the Common Reporting Table (CRT). This CRT report consists of each year's emission data, activity data, and implied emission factors. The trends of emission are provided for each greenhouse gas and for total greenhouse gas emission in CO2 equivalents.

The annual emission inventories for the years from 2020 – 2022 are reported in the Common Reporting Table (CRT). Within this submission separate CRTs are available at Department of Climate Change, Ministry of Natural Resource and Environment and (UNFCCC). The CRT spread-sheet encompass data on emission, activity data, and Implied emission factors for each year. Emission trends are given for each greenhouse gas and for total greenhouse gas emissions in CO_2 equivalent. In addition, the CRT comprises trends in greenhouse gas emissions, description of each emission category, planned improvements are procedure for quality assurance and control.

1.2. A Description of Lao PDR National Circumstance and Inventory Arrangement

1.2.1. National Entity and National Focal Point

The Lao PDR government had designated the Department of Climate Change (DCC) within the Ministry of Natural Resources and Environment (MONRE) as the national focal point for climate change. According to the resolution from the National Assembly on approving the restructure of the government’s organization (No.05/NA, dated 20 March 2025) to merge some Ministries (such as the merge of the Ministry of Energy and Mines into the Ministry of Commerce and Industry, the merge of the Ministry of Investment and Planning into the Ministry of Finance, and the merge of the Ministry of Natural Resources and Environment and the Ministry of Agriculture and Forestry (MAF) into the new Ministry of Agriculture and Environment), and change the name of the Ministry of Information Culture and Tourism to the Ministry of Culture and Tourism, effective June 2025. The Department of Climate Change continues its role and responsibilities as a coordinating agency for climate change and in spearheading the development of relevant policies.

During the technical preparation of Lao PDR's NIR, the DCC worked with the cross-ministerial, Technical Working Group on Climate Change, key stakeholders, and Development Partners. Key ministries that contributed to the NIR's development process (specifically from August 2023 to May 2025) included the former Ministry of Agriculture and Forestry, the former Ministry of Energy and Mines, the Ministry of Industry and Commerce, the former Ministry of Planning and Investment, the Ministry of Foreign Affairs, the Ministry of Labor and Social Welfare, the Ministry of Public Health, the Ministry of Information Culture and Tourism, the Ministry of Public Works and Transport, the Ministry of Finance, and the Ministry of Education and Sports.

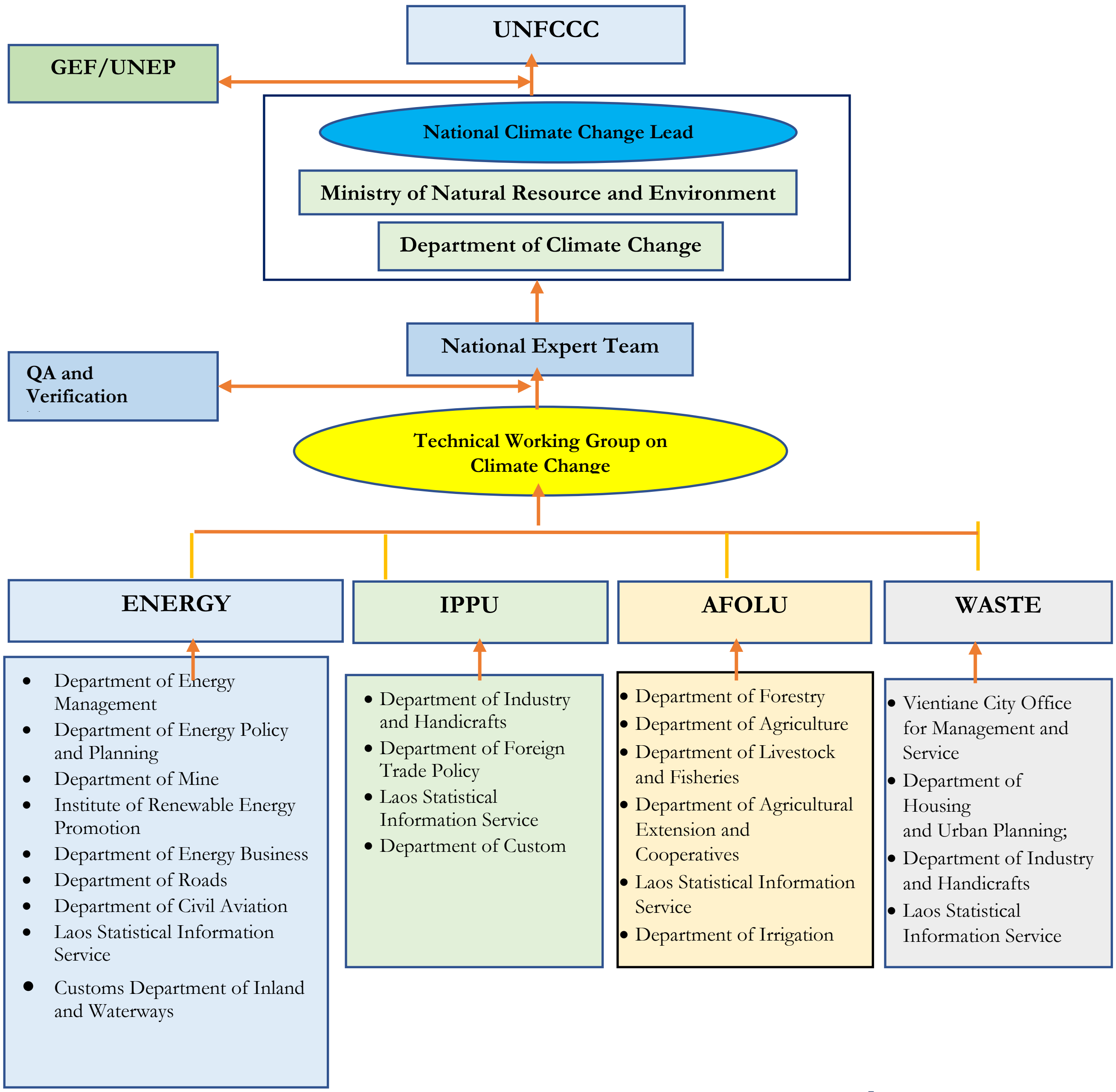


Figure 7 : Institutional Arrangement for NIR (during August 2023 – June 2025) [5]

[5] Lao PDR (2023). The Third National Communication on Climate Change, Department of Climate Change, Ministry of Natural Resource and Environment

1.2.1.1. Roles and Responsibility

This section outlines the roles and responsibilities of the relevant ministries during the technical preparation of the NIR from August 2023 to May 2025

a) Department of Climate Change, Ministry of Natural Resource and Environment

- The Department of Climate Change (DCC) acts as the national focal point for the UNFCC. Hence, DCC will not only ensure quality, relevance, and compliance with the BTR process but also ensure delivery of the BTR and communication with MONRE leadership;
- DCC will implement the BTR project, including consulting and coordination, data collection, assessment, QA/QC, validation, and reporting;
- DCC will also ensure that the BTR report, which will be submitted to UNFCC, is aligned with the 2006 IPCC Guidelines.

b) Ministry of Agriculture and Forestry (MAF)

- The department provides data for preparing GHG inventory and includes the Department of Forestry (REDD+ Division, Forest Inventory, and Planning Department), Department of Agriculture, Department of Livestock and Fisheries, National Agriculture and Forestry Research Institute;
- The MAF provides technical inputs on preparing BTR's report in each chapter, such as National Inventory Report, NDC tracking, and assessment of climate change impact under the guidance of DCC and MONRE;
- The MAF provides data that will be used for estimating GHG emissions, including livestock (Enteric Fermentation and Manure management) and land (Forest Land, Cropland, Grassland, Wetland, Settlements, and Other Land)

c) Ministry of Energy and Mine (MEM)

- The MEM provides data for preparing GHG inventory, including the Department of Energy Management, Department of Energy Business, Department of Mines Management, and Institute of Renewable Energy Promotion;
- The MEM provides technical inputs on preparing BTR's report in each chapter, such as National Inventory Report, NDC tracking, and assessment of climate change impact under the guidance of DCC and MONRE;
- The MEM provides data that will be used for estimating GHG emissions, including fuel combustion activities (Energy industries, Manufacturing Industries and Construction, Transport, and Other Sectors), Fugitive Emission from Fuels (Solid Fuels and Oil and Natural Gas), and Carbon dioxide Transport and Storage.

d). Ministry of Industry and Commerce (MOIC)

- The MOIC provides data for preparing GHG inventory, including the Department of Industry and Handicraft, the Department of Import and Export, Domestic and International Trade, and Micro-Small-Medium Enterprise Promotion;
- The data provided by the MOIM to estimate the GHG emissions, including Mineral Industry (Cement production, Lime Production, Glass Production, and Other Process Uses of Carbonates), Chemical Industry, Metal Industry, Non-Energy Products from Fuels and Solvent, Electronic Industry, Product Uses as Substitutes for Ozone Depletion, Other Product Manufacture and Use, and Other.

1.2.2. Inventory Preparation process

1.2.2.1. Timeline of Inventory Preparation

(Table 12) present the annual cycle of inventory preparation. This preparation cycle is in compliance with the LAO PDR's fiscal year calendar, which commenced on March 2024 and Ended April 2025.

Table 12 : Timeline of Inventory Preparation

Process	Fiscal Year 2024										Fiscal Year 2025					
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	No	Dec	Jan	Feb	Mar	Apr	May	Jun
Reviewed and Prepared Questionnaires	➡															
Data collection		➡	➡													
Data analysis				➡	➡	➡										
Organized consultation workshop						➡										
Preparation of the draft NIR							➡	➡	➡							
Submitting of the draft NIR										➡	➡					
Improve Draft NIR													➡			
QA of GHGs inventory management systems by UNFCCC Secretary															➡	
Improve Draft NIR based on QA section recommendation															➡	
Submission of the Final NIR																➡

1.2.2.2. Process of the Inventory Preparation

a) Organized GHG Inventory Consultation Workshop

After completing the collection of the GHG inventory data, DCC organized a consultation workshop with concerned stakeholders to confirm activity data and calibration methodology and present the result of the GHG emissions estimation. The key Departments were from the Ministry of Natural Resource and Environment, the Ministry of Industry and Commerce, the Ministry of Energy and Mines, the Ministry of Agriculture and Forestry, the Ministry of Public Work and Transport, The Ministry of Finance, and The Ministry of Planning and Investment.

b). Supported by the Ministry of the Environment of Japan (MOEJ)

To ensure the process of GHG Inventory preparation and to be submitted in a timely manner to the UNFCCC under the ETF, Lao PDR has been supported by the Ministry of the Environment of Japan (MOEJ) through the project "Support for Enhancement of Capacities for the Preparation of

GHG Inventory in a sustainable and timely manner." The project will be implemented from June 2024 to March 2025. The main activities include as follows:

- Development of fundamental knowledge on ETF, MPGs, and 2006 IPCC Guidelines, including understanding the ETF under the Paris Agreement and MPG and Clarify and solve questions on GHG inventory estimation;
- Development of a manual for GHG inventory preparation, including a Document on planning and institutional arrangement for GHG inventory preparation as a manual, a Document on data collection and methodologies as a manual, and develop an improvement plan for BTR2 after the completion of GHG inventory for BTR1;
- Be familiar with the UNFCCC reporting tool, including practical exercises on filling Common Reporting Tables (CRT) developed by the UNFCCC secretariat; clarify and solve questions on using CRT.

To achieve the activities mentioned above, the technical support for four sectors, energy, IPPU, waste, and AFOLU, is led by Mitsubishi UFJ Research and Consulting Ltd., Japan.

1.2.3. Archiving of Inventory Information

The Department of Climate Change (DCC) under the Ministry of Natural Resource and Environment will archive all GHG inventory data and information. The detailed archived information includes the following:

- NIR and CRT files submitted every two years to the UNFCCC Secretariat;
- Statistical data provided by concerned Ministries;
- Data and information on the selection of activities data, estimation methods, EFs, and the emission result during the consultation workshop with concerned stakeholders;
- Suggestions from experts' judgement on the GHG inventory;
- After submitting the NIR report to the UNFCC secretariat, the DCC will share the file with concerned stakeholders and the public via manual or electronic file.

1.2.4. Process for Official Consideration and Approval of Inventory

The GHG inventory report will be officially considered and approved by proceeding as follows:

- DCC organized the first consultation workshop with concerned stakeholders by sectors, including Energy, IPPU, AFOLU, and Waste, to present the key categories, activities data, EFs, and sources;
- DCC organized the Second consultation workshop with concerned stakeholders to present the first draft of the report, including the activities data, estimation methods, EFs, sources, and the emission result;
- DCC organized the third consultation workshop with concerned stakeholders to present an improved report. If there is no further advice for improvement, the third drafts will be considered the final versions.

1.3. Brief General Description of Methodologies (Including Tiers used and Data Source)

The national GHG inventory of Lao PDR is prepared in accordance with the recommended methods (tier level) in the 2006 IPCC Guidelines. Guidelines for classifying sub-sectors, applying decision trees, constants, conversion factors, and EFs were prioritized according to the 2006 IPCC Guidelines. The 2019 Refinement was used in case a few of the EFs, parameters, and conversion factors could not be found in the 2006 IPCC Guidelines. Sectors considered in the 2016 national GHG inventory are the Energy Sector, IPPU Sector, AFOLU Sector, and Waste Sector.

1.3.1. Data Source

The inventory is prepared applying diverse sources of activity data, including publish data from concerned stakeholders, national statistics, and international sources. The details are presented in (Table 13).

Table 13: Data Source from Each Sector

NO	Sub-Categories	Data Sources
Energy Sectors		
01	Electricity Generation (1.A.1.a.i)	• The data for 2018 and 2022 were obtained from the Department of Planning and Finance, Ministry of Energy and Mine, while the data for 2019 to 2021 were estimated by applying an interpolation formula
02	Non-Specified Industry (1.A.2.m)	• The total amount of solid fuels (anthracite and lignite) and oil products data for 2020 and 2021 were taken from the IEA website while the data for 2022 was calculated by applying extrapolation formula; • The total amount of biomass consumption (wood/wood waste) data for 2020 and 2021 was taken from the IEA website, while the data for 2022 was calculated by applying an extrapolation formula;
03	International Aviation (1. A.3.a.i)	• The fuel consumption data of international aviation for 2020, 2021, and 2022 was obtained from the Department of Civil Aviation, Ministry of Public Work and Transport.
04	Domestic Aviation (1.A.3.a.ii)	• The total fuel consumption data of domestic aviation for 2020 and 2021 were obtained from IEA website while the fuel consumption data for 2022 was calculated by applying the Extrapolation formula.
05	Cars (1. A.3.b.i)	• The total fuel consumption data of the car for 2020 and 2021 were obtained from the IEA website while the fuel consumption data for 2022 was calculated by applying the Extrapolation formula. •
06	Off-Road (1.A.3.e.ii)	• The fuel consumption data of the Off-road for 2020, 2021, and 2022 was obtained from the Department of Civil Aviation, Ministry of Public Work and Transport.
07	Commercial/Institutional (1.A.4.a)	• The fuel consumption data of the Liquefied Petroleum Gas (LPG) for 2020 and 2021 was obtained from the IEA website while the fuel consumption data for 2022 was calculated by applying an Extrapolation formula; • The total amount of wood/wood waste and charcoal for 2020 and 2021 were obtained from the IEA website; while the data for 2022 was calculated by applying extrapolation. • The aggregated fuel consumption data ratio of the wood/wood waste and charcoal for 2020 and 2021 were calculated based on the ratio value from the **source:** Lao PDR Energy Statistics 2018, Table 1.12, Department of Energy and Planning, Ministry of Energy and Mines, Lao PDR and data from 2022 was calculated by applying extrapolation.
08	Residential (1.A.4.b)	• The fuel consumption data of the Liquefied Petroleum Gas (LPG) for 2020 and 2021 was obtained from the IEA website while the fuel consumption data for 2022 was calculated by applying an extrapolation formula; • The total amount of wood/wood waste and charcoal for 2020 and 2021 were obtained from the IEA website; while the data for 2022 was calculated by applying extrapolation. • The aggregated fuel consumption data ratio of the wood/wood waste and charcoal for 2020 and 2021 were calculated based on the ratio value from the **source:** Lao PDR Energy Statistics 2018, Table 1.12, Department of Energy and Planning, Ministry of Energy and Mines, Lao PDR and data from 2022 was calculated by applying extrapolation formula.

09	Off-Road Vehicles and Other Machinery (1.A.4.c.ii)	• The fuel consumption data for the Diesel oil for 2020 – 20221 was obtained from IEA website while the fuel consumption data for 2022 was calculated by applying extrapolation formular.
10	Mining (1.B.1.a.ii.1)	• The amount of coal produced for 2020, 2021, and 2022 were obtained from Statistical Years Book for 2019,2020, and 2022, Lao Statistic Bureau, Ministry of Planning and Investment (MPI)
IPPU Sectors		
11	Cement Production (2. A.1)	• The Cement production for 2020, 2021, and 2022 was obtained from Lao Statistical Information Service (LAOSIS), Ministry of Investment and Planning
12	Lime Production (2.A.2)	• The total amount of Lime Production data for 2022 was taken from statistical Yearbook Energy and Mine 2022 (MEM), and data for 2015 backward were taken from Statistical Yearbook 2015, Lao Statistics Bureau, Ministry of Planning and Investment, while the data for 2016 to -2021 was calculated by applying interpolation formula
13	Iron and Steel Production (2.C.1)	• Lao Statistical Yearbook 2022 & 2021
14	Lubricant Use (2.D.1)	• The Total Lubricant Consumption data, including Lubricant Preparations, Other Lubricant, Preparation containing silicone oil, and Preparations for aircraft engines for 2020, 2021, and 2022 was obtained from Lao Trade Statistic System • The NCV value was taken from IPCC Guideline 2006, Chapter 1, Volume 2, Table 1.2, Page 1.18
15	Paraffin Wax (2.D.2)	• The total Paraffin Wax consumption data for 2020, 2021, and 2022 was obtained from Lao Trade Statistic System; • The total Paraffin Wax, containing < 0.75% oil for 2020 was obtained from world Integrated Trade Solution
16	Refrigeration and Air Conditioning (2.F.1.a)	LAO PDR – Kigali HFCs Implementation Plan Stage 1, Table 10: Parameters used to calculate HFCs usage in servicing sector and fire suppression in Lao PDR
17	Mobile Air Conditioning (2.F.1.b)	• LAO PDR – Kigali HFCs Implementation Plan Stage 1, Table 10: Parameters used to calculate HFCs usage in servicing sector and fire suppression in Lao PDR
Agriculture Sectors		
18	Enteric Fermentation (3.A.1)	Default value (2006 IPCC Guidelines, Vol.4 Equations 10.19 and 1020, Chapter 10, Page 10.28)
19	Manure Management (3.A.2)	Default values (2006 IPCC Guidelines, Table 10.14, p.10.39 and Table 10.15, Page. 10.40 for manure management and use default values, Table 10.19, Page. 10.59 for nitrogen excretion rate
20	Burning (3.C.1)	National Statistics (Area burnt); 2006 IPCC guidelines (mass of fuel consumed); and FAO statistics
21	Liming (3.C.2)	World integrated Trade
22	3.C.3 - Urea application	FAO Statistics
23	Direct N_2O Emissions from managed soils (3.C.4)	Calculated (utilizing FAO database, Agricultural statistics)
24	Indirect N_2O Emissions from managed soils (3.C.5)	Calculated (utilizing FAO database, Agricultural statistics)
25	Indirect N_2O Emissions from Manure management (3.C.6)	N excretion as the calculation in the manure management category of the inventory
LULUCF		

26	Forest Land (FL) (3.B.1.)	• MAF (2018). Lao People's Democratic Republic Forest Reference Emission Level and Forest Reference Level for REDD+ Results Payment under the UNFCCC; • As there is no annual reports on area change, this inventory is applied gap (4-5 years) area data for tracking. Tracking determines the last year of each period data as a year of conversion (e.g., from the data of 2019-2022, the conversion year is 2022; • Conversion year is a default value from the Chapter 4, Vol.4, 2006 IPCC Guidelines; • DOM-in is calculated by using default values from Chapter 2, Vol.4 of the guidelines (See page 2.25, Section 2.3.2.2); • DOM-out is calculated by using default values from Chapter 2, Vol.4 of the guidelines; • Chaplot, Vincent & Bouahom, Bounthong & Valentin, Christian. (2009). Soil organic carbon stocks in Laos: Spatial variations and controlling factors. Global Change Biology.
27	Harvested Wood Products (HWP) (3.D.1)	
28	Cropland (CL) (3.D.2.)	
29	. Other Land (OH) (3.D.3)	
30	. Settlement (SL) (3.D.4)	
31	. Grassland (GL) (3.D.5)	
32	Wetland (WL) (3.D.6.)	
33		
34	Rice cultivation (3.C.7)	Agricultural Statistics Yearbook 2022
Waste Sectors		
35	Unmanaged Waste Disposal Sites (4.A.2)	• World Bank (2024). Population, Total – Lao PDR; • LAOSIS (2024). Population by province; • World Bank, 2021. Supporting Lao PDR to Improve Solid and Plastic Waste Management, Table 2, Page 13; • GGGI (2021). Sustainable Solid Waste Management, Strategy and Action Plan 2021-2030, Chapter 1, Figure 2, page 14; • VUDAA (2024). Waste Data Collection on Clinical Waste Report, Page 7, Vientiane Capital; • Deevanhxay, P (2022). A Baseline Survey on Current Situation and Performance of Domestic Wastewater Treatment System in Lao PDR, Faculty of Natural Science, National University of Laos, Page 22; • MOIC (2021). Development plan on manufacturing and handicraft sectors, Ministry of Industry and Commerce, Laos, Annex 1, page 60
36	Uncategorized Waste Disposal Site (4.A.3)	
37	Waste Incineration (4.C.1)	
38	Domestic Wastewater Treatment and Discharge (4.D.1)	
39	Industrial Wastewater Treatment and Discharge (4.D.2)	

1.3.2. Emission Factors

Table 14: Emission Factor for Four Sectors

NO	Sub-Categories	Tiers	Emission Factors
Energy Sectors			
01	Electricity Generation (1.A.1.a.ii)	Tier 1	Default value (2006 IPCC Guidelines, Table 2.2, Pages 2.16–2.17, Volume 2, Chapter II)
02	Non-Specified Industry (1.A.2.m)	Tier 1	Default value (2006 IPCC Guidelines, Table 2.2, Pages 2.16–2.17, Volume 2, Chapter II)
03	International Aviation (1. A.3.a.i)	Tier 1	Default value (2006 IPCC Guidelines, Table 2.2, Pages 2.16–2.17, Volume 2, Chapter II)
04	Domestic Aviation (1.A.3.a.ii)	Tier 1	Default value (2006 IPCC Guidelines, Table 2.2, Pages 2.16–2.17, Volume 2, Chapter II)
05	Cars (1. A.3.b.i)	Tier 1	Default value (2006 IPCC Guidelines, Table 2.2, Pages 2.16–2.17, Volume 2, Chapter II)
06	Off-Road (1.A.3.e.ii)	Tier 1	Default value (2006 IPCC Guidelines, Table 2.2, Pages 2.16–2.17, Volume 2, Chapter II)
07	Commercial/Institutional (1.A.4.a)	Tier 1	Default value (2006 IPCC Guidelines, Table 2.4, Pages 2.20 – 2.21, Volume 2, Chapter II)

08	Residential (1.A.4.b)	Tier 1	Default value (2006 IPCC Guidelines, Table 2.4, Pages 2.20 – 2.21, Volume 2, Chapter II)
09	Off-Road Vehicles and Other Machinery (1.A.4.c.ii)	Tier 1	Default value (2006 IPCC Guidelines, Table 2.4, Pages 2.20 – 2.21, Volume 2, Chapter II)
10	Mining (1.B.1.a.ii.1)	Tier 1	Default value (2006 IPCC Guidelines, Chapter IV, Volume 2, Page 4.19)
IPPU Sectors			
11	Cement Production (2. A.1)	Tier 1	Default value (2006 IPCC Guidelines, Equation 2.4, Volume 3, Chapter 2, Page 2.12 with the value of 0.52 tonnes CO_2/tonne Clinker) Default value (The emission factor for clinker corrected for CKD was 1.02 tonnes CO_2/tonne clinker (IPCC 2006, Equation 2.4, Volume 3,
12	Lime Production (2.A.2)	Tier 1	Default value (2006 IPCC Guidelines, Equation 2.8, Chapter 2, Page 2.22).
13	Iron and Steel Production (2.C.1)	Tier 1	Default value (2006 IPCC Guidelines, Chapter IV, Volume 3, Table 4.1, Page 4.25).
14	Lubricant Use (2.D.1)	Tier 1	The default carbon contents factor of lubricant type (tonne C/TJ) was 20 kg C/GJ (2006 IPCC Guidelines, Chapter V, Volume 3, Page 5.9); The Oxidised During Use (ODU) factor for lubricant type was 0.2 (2006 IPCC Guidelines, Chapter V, Volume 3, Table 5.2, Page 5.9);
15	Paraffin Wax (2.D.2)	Tier 1	The carbon content of Paraffin wax (tonne C/TJ) was 20 kg C/GJ (2006 IPCC Guidelines, Chapter V, Volume 3, Page 5.12); The Oxidised During Use (ODU) factor for Paraffin type was 0.2 (2006 IPCC Guidelines, Chapter V, Volume 3, Table 5.2, Page 5.12);
16	Refrigeration and Air Conditioning (2. F.1.a)	Tier 1	LAO PDR - Kigali HFCs Implementation Plan Stage 1, Table 10: Parameters used to calculate HFCs usage in servicing sector and fire suppression in Lao PDR
17	Mobile Air Conditioning (2.F.1.b)	Tier 1	Lao People's Democratic Republic HCFC Phase-Out Management Plan Stage II
Agriculture Sectors			
18	Enteric Fermentation (3.A.1)	Tier 1	Default value (2006 IPCC Guidelines, Equations 10.19 and 1020, Chapter 10, Page 10.28)
19	Manure Management (3.A.2)	Tier 1	Default values (2006 IPCC Guidelines, Table 10.14, p.10.39 and Table 10.15, Page. 10.40 for manure management and use default values, Table 10.19, Page. 10.59 for nitrogen excretion rate
20	Burning (3.C.1)	Tier 1	Equation 2.27 (2006 IPCC Guidelines, Chapter 2, Page 2.42) is a generic methodology to estimate the emissions of individual greenhouse gases for any type of fire; default values for the amount of fuel actually are given in Table 2.4; default values of emission factors for various types of burning are available in Table 2.5; default combustion factor values for fires in a range of vegetation types are provided in Table 2.6 (2006 IPCC Guidelines, Chapter 2, Page 2.45- 2.48)
21	Liming (3.C.2 -)	Tier 1	Equation 2.27 (2006 IPCC Guidelines, Chapter 2, Page 2.42) is a generic methodology to estimate the emissions of individual greenhouse gases for any type of fire; default values for the amount of fuel actually are given in Table 2.4; default values of emission factors for various types of burning are available in Table 2.5; default combustion factor values

			for fires in a range of vegetation types are provided in Table 2.6 (2006 IPCC Guidelines, Chapter 2, Page 2.45- 2.48)
22	Urea application (3.C.3)	Tier 1	Equation 11.13 (2006 IPCC Guidelines, Chapter 11, Page 11.32) is used to estimate CO_2 emissions from urea fertilization; the default emission factor (EF) for carbon emissions from urea applications is provided in Section 11.4.2 (2006 IPCC Guidelines, Chapter 11, Page 11.34)
23	Direct N_2O Emissions from managed soils (3.C.4)	Tier 1	Equation 11.1 (2006 IPCC Guidelines, Chapter 11, Page 11.6) is used to estimate direct N_2O emissions from managed soils; default emission factors to estimate direct N_2O emissions from managed soils are available in Table 11.1 (2006 IPCC Guidelines, Chapter 11, Page 11.11); default factors for estimation of n added to soils from crop residues are provided in Table 11.2 (2006 IPCC Guidelines, Chapter 11, Page 11.17)
25	Indirect N_2O Emissions from managed soils (3.C.5)	Tier 1	Equation 11.9 (2006 IPCC Guidelines, Chapter 11, Page 11.21) is used to estimate N_2O emissions from atmospheric deposition of N volatilized from managed soil; Equation 11.10 (2006 IPCC Guidelines, Chapter 11, Page 11.21) is used to estimate N_2O emissions from leaching and runoff in regions where leaching and runoff occurs; default emission, volatilization and leaching factors for indirect soil N_2O emissions are given in Table 11.3 (2006 IPCC Guidelines, Chapter 11, Page 11.24); the default FracLEACH-(H) for humid regions is available in Section 11.2.2.2.
26	Indirect N_2O Emissions from manure Management (3.C.6)	Tier 1	Equation 10.26 (2006 IPCC Guidelines, Chapter 10, Page 10.54) is used to estimate N losses due to volatilization from manure management; Equation 10.27 (2006 IPCC Guidelines, Chapter 10, Page 10.56) is used to estimate indirect N_2O emissions due to volatilization of N from manure management; default management system allocations are given in Annex 10A.2, Tables 10A-4 to 10A-8 (2006 IPCC Guidelines, Chapter 10, Page 10.77 – 10.81); default fractions of N losses from manure management systems due to volatilization are available in Table 10.22 (2006 IPCC Guidelines, Chapter 10, Page 10.65); emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces is given in Table 11.3 (2006 IPCC Guidelines, Chapter 11, Page 11.24)
27	Rice cultivation (3.C.7)	Tier 1	Equation 10.26 (2006 IPCC Guidelines, Chapter 10, Page 10.54) is used to estimate N losses due to volatilization from manure management; Equation 10.27 (2006 IPCC Guidelines, Chapter 10, Page 10.56) is used to estimate indirect N_2O emissions due to volatilization of N from manure management; default management system allocations are given in Annex 10A.2, Tables 10A-4 to 10A-8 (2006 IPCC Guidelines, Chapter 10, Page 10.77 – 10.81); default fractions of N losses from manure management systems due to volatilization are available in Table 10.22 (2006 IPCC Guidelines, Chapter 10, Page 10.65); emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces is given in Table 11.3 (2006 IPCC Guidelines, Chapter 11, Page 11.24)
	LULUCF Sectors		
28	Forest Land (FL) (3.B.1)	Tier 1	Since Lao PDR has not had the country-specific estimates of activity data and emission/removal, Tier 1 approach has been applied

29	Cropland (CL) (3.B.2)	Tier 1	Since Lao PDR has not had the country-specific estimates emission/removal of Land converted to Cropland, Tier 1 approach has been applied
30	Grassland (GL) (3.B.3)	Tier 1	Since Lao PDR has not had the country-specific estimates emission/removal of the Grassland Remaining Grassland, Tier 1 approach is used.
31	Wetland (WL) (3.B.4-)	Tier 1	Since Lao PDR has not had the country-specific estimates emission/removal of wetland converted to Cropland, Tier 1 approach has been applied
32	Settlement (SL) (3.B.5)	Tier 1	Changing the living biomass stock of land converted to settlements was calculated by applying Equation 2.16, Page 2.20, Chapter 2, Volume 2, the 2006 IPCC Guidelines
33	Other Land (OH) (3.B.6)	Tier 1	The living biomass carbon stock change of land converted to other land was calibrated by applying Equation 2.16, Page 2.20, Chapter 2, Volume 4, 2006 IPCC Guidelines.
34	3.D.1Harvested Wood Products (HWP) (3.D.1)	Tier 1	Tier 1 method, 2006 IPCC Guidelines, Chapter 12, Table 12.2, Page 12.17 is used
Waste Sectors			
35	Unmanaged Waste Disposal Sites (4.A.2)	Tier 1	Default value (2006 IPCC Guidelines, Table 3.1, page 3.14, Volume 5, Chapter 3)
36	Uncategorized Waste Disposal Site (4.A.3)	Tier 1	Default value (2006 IPCC Guidelines, Table 3.1, page 3.14, Volume 5, Chapter 3)
37	Waste Incineration (4.C.1)	Tier 1	Default value (2006 IPCC Guidelines, Table 5.2, page 5.18, Volume 5, Chapter 5)
38	Domestic Wastewater Treatment and Discharge (4.D.1)	Tier 1	Default value (2006 IPCC Guidelines, Chapter 6, Volume 5, Table 6.2, Page 6.12); Default value (2006 IPCC Guidelines, Chapter 6, Volume 5, Table 6.11, Page 6.26); Default value (2006 IPCC Guidelines, Chapter 6, Volume 5, Table 6.11, Page 6.26)
39	Industrial Wastewater Treatment and Discharge (4.D.2)	Tier 1	Default value (2006 IPCC Guidelines, Chapter 6, Volume 5, Table 6.2, Page 6.12)

Global Warming Potential Values (GWP)

The 100-year time-horizon global warming potential (GWP from the IPPC Fifth Assessment Report) is used for estimating the national GHG inventory for 2022 (Table 15).

Table 15: Global Warming Potential Value (GWP)

Gases		GWP	Source
CO_2		1	**AR5, IPCC**
CH_4		28	
N_2O		265	
HFCs	HFCs -32	650	
	R-410A		
	R-404		
	HFCs -134a	1300	
	HFCs -407C		

1.4. Briefs Description of Key Categories

The key categories analysis was conducted in compliance with the 2006 IPCC Guidelines, including Approach 1, Level 1, and Trend assessment, for all inventory categories and for both case of including and excluding the LULUCF sector.

The analysis result found that, in case of including the LULUCF sector, there were **11** Key categories sources. In case of excluding LULUCF sector, there were **14** key categories for the year 2022. The detailed is presented in (Executive Summary E.S.3)

1.5. Brief Description of the QA/AC Plan and Implementation

The major element of a QA/QC and verification system to be implemented in tracking inventory compilation, covering in detail as follows:

- Participation of an inventory compiler who is also responsible for according QA/QC and verification activities and definition of roles and responsibility within the inventory;
- A QA/QC plan;
- General QC procedures that apply to all inventory categories;
- QA and review procedures;
- QA/QC system interaction with uncertainty analysis;
- Verification activities;
- Reporting, documentation, and archiving procedures

The detailed of the QA/QC process in Lao PDR included in **Annex 3**

1.6 Summary of any flexibility applied

Due to the limited historical data on Greenhouse gas emissions, Laos reports its annual time series from 2020 until 2022 instead of 1990 until 2022, as detailed in paragraph 57 of Decision 18/CMA.1.Laos also applies the flexibility provisions of paragraph 48 of Decision 18/CMA.1 Report only four gases (CO_2, CH4, N2O, and HFC) out of 7 gases (CO_2, CH4, N2O, HFCs, PFCs, SF6 and NF3). PFCs, SF6, and NF3 gases were not included in previous inventory reports or in NDC 2.0 due to the lack of activity data and their relatively low emission levels compared to other reported gases. NDC 2.0 does not include activities under Article 6, as its primary goal is to contribute to overall emission reductions and achieve net-zero emissions by 2050. Another flexibility applied is Uncertainty assessment, as detailed in paragraph 29 of Decision 18/CMA.1, where the report presents a qualitative discussion of uncertainty for key categories where quantitative input data are unavailable. Lastly, due to the delay in implementing the BTR project and the lack of resources and internal experts, Lao was unable to submit its national inventory report by 2024 but has scheduled it for 2025. As a result, the flexibility is outlined in paragraph 58 of Decision 18/CMA.1 (Time series) was also applied, where the latest reporting year is three years, rather than two years, before the national inventory report submission.

For the future BTR, there should be an improvement in applying complete requirements based on the best capacity and resources given.

CHAPTER II: GHG EMISSION TRENDS

2.1. Description and Interpretation of Emission and Removal Trends for Aggregate GHGs

The greenhouse gas emissions are computed based on the 2006 IPCC Guidelines and are aggregated into five sectors: Energy, IPPU, Agriculture, LULUCF, and Waste Sector. The greenhouse gases obtained from the mentioned sectors encompassed CO_2, CH_4, N_2O, and HFCs, (Figure 08) presents total greenhouse gas emissions by Sectors excluding LULUCF from 2020 – 2022.

In 2022, the Energy sector is the most significant source emission, accounting for 21,688.98 Gg CO_2 eq or 55.84 % followed by Agriculture sector, accounting for 10,480.02 Gg CO_2 eq or 26.98 %, IPPU is accounted for 5,226.55 Gg CO_2eq or 13.46 % and Waste is accounted for 1,448.49 Gg CO_2 eq or 3.73 % (Figure 8).

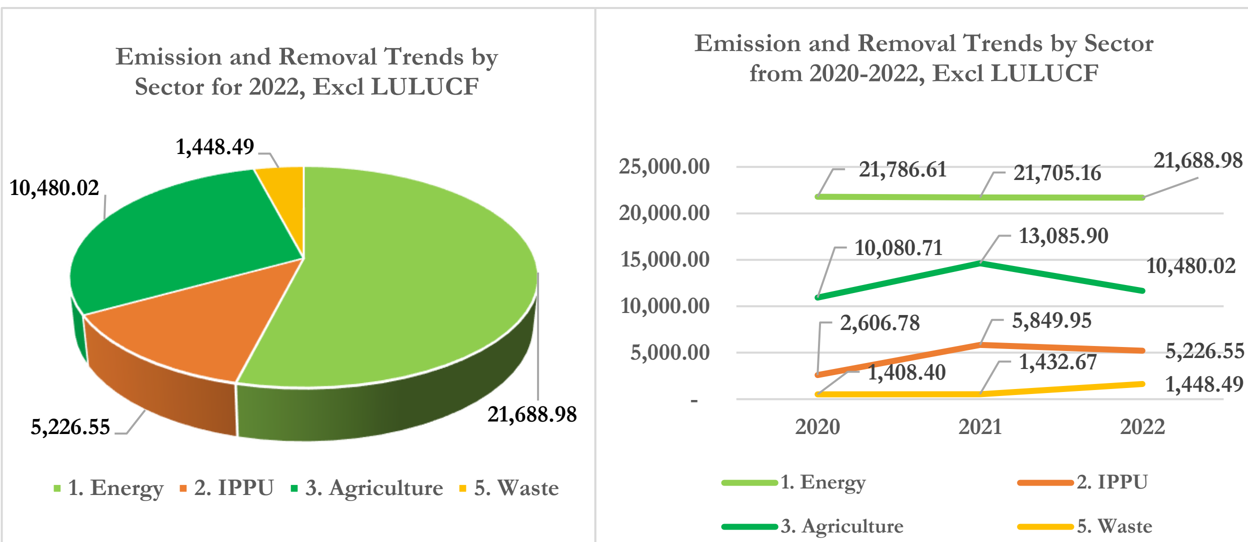


Figure 8: Emission and Removal by Sector for 2022 and Time Series for 2022 - 2022

2.2. Description of Emission and Removal Trends by Sector and by Gas (Excl LULUCF)

2.2.1. Carbon Dioxide (CO2)

The largest source of CO_2 emission for 2022 is driven from the Energy sector, covering 20,651.65 (GgCO_2 eq) or 80.38 %, followed by IPPU sector, accounting for 5,026.52 (GgCO_2 eq) or 19.56% while Agriculture sector is accounted for 13.85 (GgCO_2 eq) or 0.05% and Waste sector is accounted for 0.17 (GgCO_2 eq) or 0.001 %. The reasons that the source of CO_2 emission increases more than others are because of the higher consumption in Energy industries, manufacturing industries, and construction and transport.

Regarding the trends in 2022 compared to the year 2020, it found that the CO_2 emission from the Energy sector has decreased by 0.66% compared to the year 2020, while the CO_2 emission in the

IPPU sector has increased by 106,37%, the agriculture sector has increased by 2.29%, and the Waste sector has increased 112.50% (Figure 9).

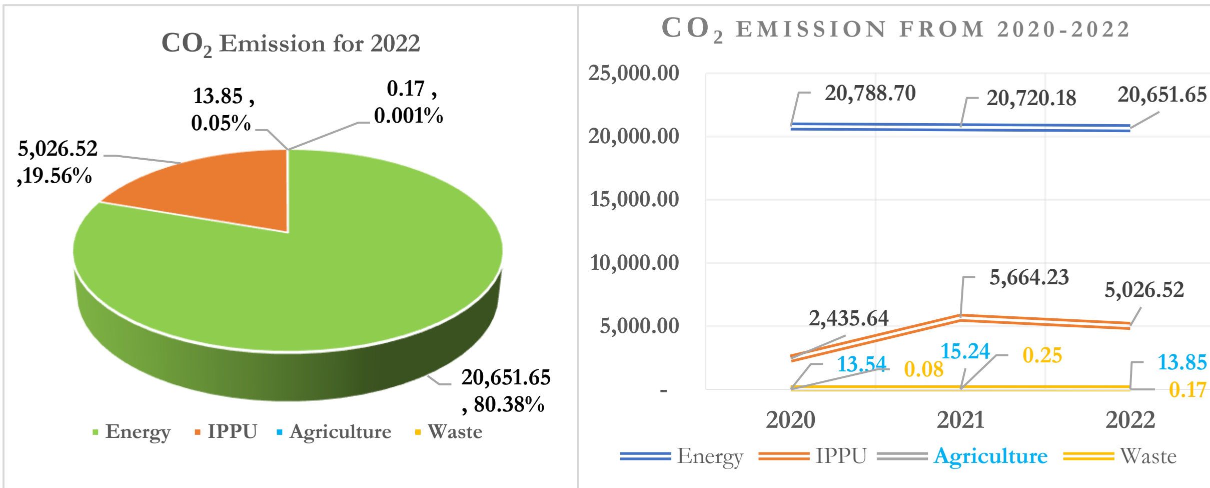


Figure 9: Emission and Removal Trends by CO2 for 2022 and Time Series for 2020 – 2022

2.2.2. Methane (CH4)

The largest source of CH_4 emission for 2022 is driven by the agriculture sector, comprising 6,5757.24(Gg CO_2 eq) or 74.26 %, followed by the Waste sector, accounting for 1,403.92 (Gg CO_2 eq) or 15.86 % and the Energy sector, accounting for 875.00(Gg CO_2 eq) or 9.88% while there is no CH_4 emission released from the IPPU sector. The main sources of CH_4 emission in the agriculture sector are enteric fermentation, manure management, burning in Forest land, Cropland, Grassland, and Rice cultivation. Regarding the trends from the years 2020 and 2022, it shows that the CH_4 emission in 2022 from the agriculture increased by 1.65% compared to the year 2020, the Energy sector increased by 4.86%, and the Waste sector increased by 2.83% (Figure 10).

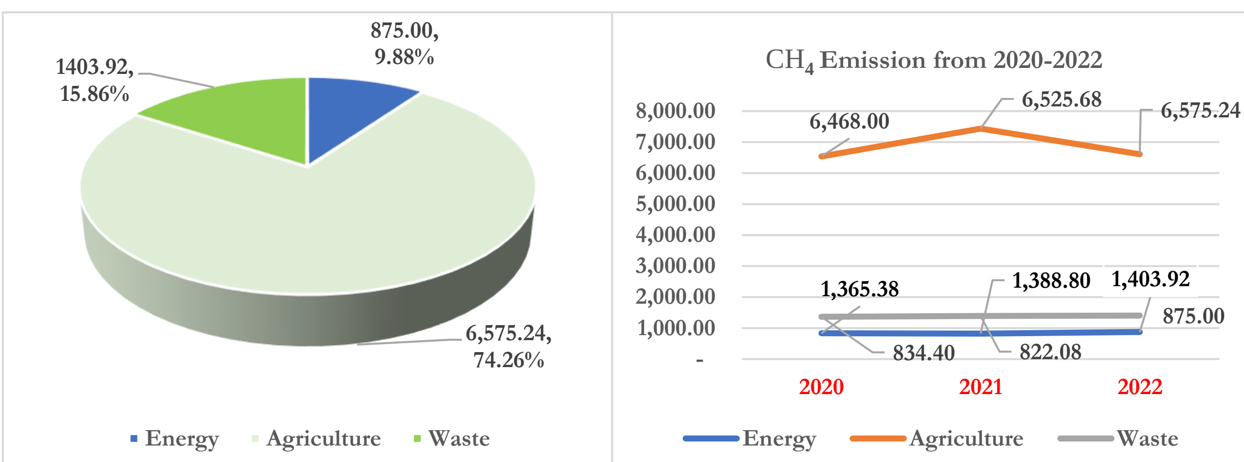


Figure 10: Emission and Removal Trends by CH4 for 2022 and Time Series for 2020 – 2022

2.2.3. Nitrous Oxide (N2O)

The largest source of Nitrous Oxide (N_2O) emission for 2022 is driven by the agriculture sector, encompassing 3,890.20 (GgCO_2 eq) or 94.95%, followed by the Energy sector, accounting for 161.65 (GgCO_2 eq) or 3.95% and Waste sector, accounting for 45.05 (GgCO_2 eq) or 1.1% while there is no Nitrous Oxide (N_2O) emission released from the IPPU sector. The primary sources of nitrogen oxide (N_2O) emission from the agricultural sector are manure management, burning in forest land, cropland, grassland, and rice cultivation.

The trends from the years 2020 and 2022 found that the Nitrous Oxide (N_2O) emission in 2022 from the agriculture sector increased by 8.1% compared to the year 2020, the Waste sector increased by 6.25%, and the Energy sector decreased by 1.61% (Figure 11).

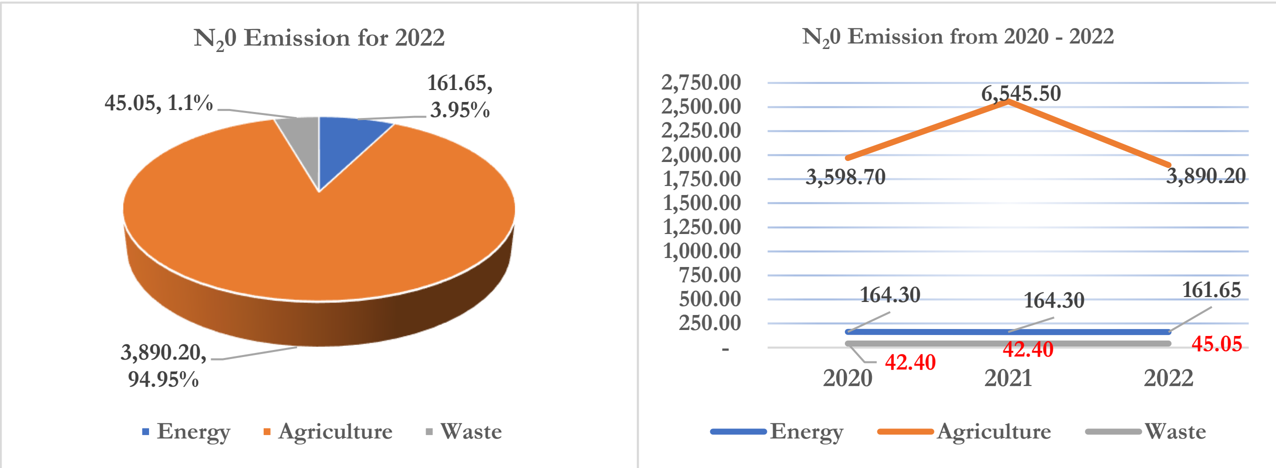


Figure 11: Emission and Removal Trends by (N2O) for 2022 and Time Series for 2020 - 2022

2.2.4. Hydrofluorocarbons (HFCs)

The total HFCs emission for 2022 was 200.02 $GgCO_2eq$. The change of HFCs increased 16.87 % compared to the year 2020

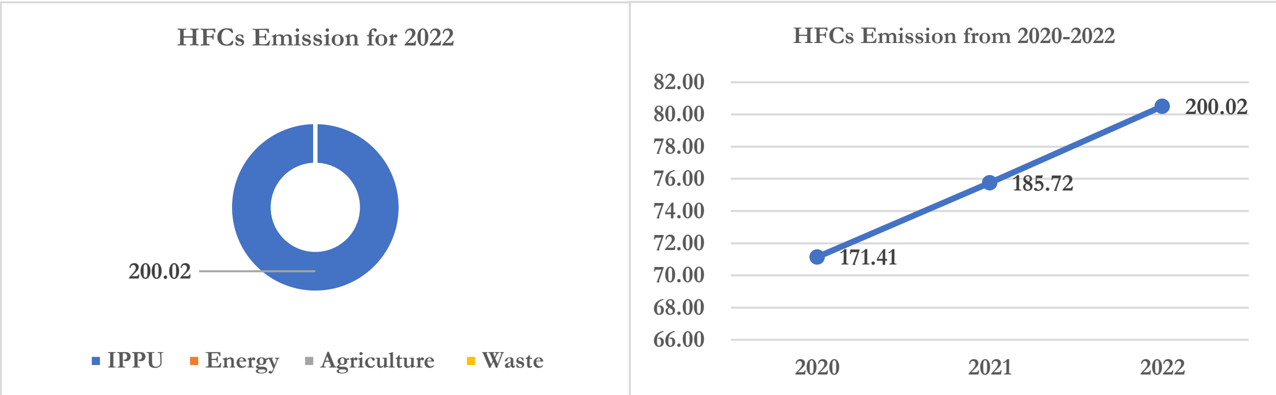


Figure 12: HFCs Emission for 2022 and Time Series for 2020 -2022

CHAPTER III: ENERGY SECTOR

3.1. Overview of the Energy Sector

The greenhouse gas (GHG) emissions in the Energy Sector include CO_2, CH_4, and N_2O. These emissions were estimated from three primary sources: Fuel Combustion Activities (1A), Fugitive Emissions from Fuels (1B), and Carbon Dioxide Transport and Storage (1.C). The total emissions from the Energy Sector were 21,688.98 $GgCO_2eq$. The largest emission source was CO_2, accounting for 20,651.647 $GgCO_2eq$, followed by CH_4 emissions at 874.88 $GgCO_2eq$, and N_2O emissions at 162.45 $GgCO_2eq$. The GHG emissions in the Energy Sector for 2022 are presented in (Table 16).

Table 16: GHG Emissions from the Energy Sector for 2022

Categories (2022)	Global Warming Potential_ AR5 Emission ($GgCO_2$ eq)			Total GHG emissions
	CO_2	CH_4	N_2O	
Total Energy	**20,651.647**	**874.884**	**162.451**	**21,688.982**
1.A. Fuel combustion activities (sectoral approach)	**20,651.647**	**469.332**	**162.451**	**21,283.431**
1.A.1. Energy industries	16,817.409	5.140	66.790	16,889.338
1.A.1.a. public electricity and heat production	16,817.409	5.140	66.790	16,889.338
1.A.2. Manufacturing industries and construction	1,208.901	4.971	6.866	1,220.737
1.A.2.g. Other	1,208.901	4.971	6.866	1,220.737
1.A.3. Transport	2,546.721	9.399	34.585	2,590.705
1.A.3.a. Domestic aviation	9.939	0.002	0.074	10.014
1.A.3.b. Road transportation	2,536.566	9.397	34.490	2,580.452
1.A.3.c. Railways	NE	NE	NE	NE
1.A.3.d. Domestic navigation	NE	NE	NE	NE
1.A.3.e. Other transportation	0.216	0.000	0.022	0.239
1.A.4. Other sectors	78.617	449.823	54.210	582.650
1.A.4.a. Commercial/institutional	47.136	94.258	11.751	153.145
1.A.4.b. Residential	30.667	355.563	42.375	428.605
1.A.4.c. Agriculture/forestry/fishing	0.815	0.001	0.083	0.900
1.B. Fugitive emissions from fuels	**-**	**405.551**	**-**	**405.551**
1.B.1. Solid fuels	-	405.551	-	405.551
1.B.1.a. Coal mining and handling	-	405.551	-	405.551

Table 17. Methodologies used in the Energy Sector

Categories	CO_2		CH_4		N_2O	
	Method applied	EF	Method applied	EF	Method applied	EF
1.A - Fuel Combustion Activities	T1	D	T1	D	T1	D
1.A.1 - Energy Industries	T1	D	T1	D	T1	D
1.A.2 - Manufacturing Industries and Construction	T1	D	T1	D	T1	D
1.A.3 - Transport	T1	D	T1	D	T1	D
1.A.4 - Other Sectors	T1	D	T1	D	T1	D
1.B - Fugitive emissions from fuels	T1	D	T1	D	T1	D
1.B.1 - Solid Fuels	T1	D	T1	D	T1	D
1.B.2 - Oil and Natural Gas						

1.B.3 - Other emissions from Energy Production						
1.C - Carbon dioxide Transport and Storage						
1.C.1 - Transport of CO_2						
1.C.2 - Injection and Storage						
1.C.3 - Other						

Note: D: IPCC default value, T1: Tier 1 approach

3.1.1. Key Categories of the Energy Sector

Table 18. Key Categories of Energy Sector (Including LULUCF) for 2022

No	A Code	B Category	C GHGs	AP1-L 2022	AP1-T 2020-2022
#3	1.A.1	Energy Industries - Solid Fuels	CO_2	#3	#3
#10	1.A.3.b	Road Transportation - Liquid Fuels	CO_2	#10	
#13	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2		
#18	1.A.4	Other Sectors - Biomass - solid	CH_4		
#20	1.B.1.a	Coal mining and handling	CH_4		
#22	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2		
#25	1.A.4	Other Sectors - Liquid Fuels	CO_2		
#26	1.A.1	Energy Industries - Solid Fuels	N_2O		
#29	1.A.4	Other Sectors - Biomass - solid	N_2O		
#31	1.A.3.b	Road Transportation - Liquid Fuels	N_2O		
#34	1.A.3.a	Civil Aviation - Liquid Fuels	CO_2		
#35	1.A.3.b	Road Transportation - Liquid Fuels	CH_4		
#37	1.A.1	Energy Industries - Solid Fuels	CH_4		
#39	1.A.2	Manufacturing Industries and Construction - Solid Fuels	N_2O		
#40	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CH_4		
#41	1.A.2	Manufacturing Industries and Construction - Biomass - solid	N_2O		
#42	1.A.2	Manufacturing Industries and Construction - Biomass - solid	CH_4		
#44	1.A.1	Energy Industries - Biomass - solid	N_2O		
#46	1.A.1	Energy Industries - Biomass - solid	CH_4		
#47	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	N_2O		
#48	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CH_4		
#49	1.A.3.e	Other Transportation - Liquid Fuels	CO_2		
#50	1.A.4	Other Sectors - Liquid Fuels	CH_4		
#53	1.A.4	Other Sectors - Liquid Fuels	N_2O		
#54	1.A.3.a	Civil Aviation - Liquid Fuels	N_2O		
#55	1.A.3.e	Other Transportation - Liquid Fuels	N_2O		
#56	1.A.3.a	Civil Aviation - Liquid Fuels	CH_4		
#57	1.A.3.e	Other Transportation - Liquid Fuels	CH_4		

Note 1: Ap1-L: Approach 1-Level Assessment, Ap1-T: Approach 1-Trend Assessment
Note 2: Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

Table 19. Key categories of the Energy Sector (Excluding LULUCF), for 2022

No	A Code	B Category	C GHGs	AP1-L	AP1-T
#1	1.A.1	Energy Industries - Solid Fuels	CO_2	#1	#2
#5	1.A.3.b	Road Transportation - Liquid Fuels	CO_2	#5	#7
#8	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	#8	
#12	1.A.4	Other Sectors - Biomass - solid	CH_4		
#14	1.B.1.a	Coal mining and handling	CH_4		
#15	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2		#3
#18	1.A.4	Other Sectors - Liquid Fuels	CO_2		

#19	1.A.1	Energy Industries - Solid Fuels	N_2O		
#22	1.A.4	Other Sectors - Biomass - solid	N_2O		
#24	1.A.3.b	Road Transportation - Liquid Fuels	N_2O		
#26	1.A.3.a	Civil Aviation - Liquid Fuels	CO_2		
#27	1.A.3.b	Road Transportation - Liquid Fuels	CH_4		
#29	1.A.1	Energy Industries - Solid Fuels	CH_4		
#31	1.A.2	Manufacturing Industries and Construction - Solid Fuels	N_2O		
#32	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CH_4		
#33	1.A.2	Manufacturing Industries and Construction - Biomass - solid	N_2O		
#34	1.A.2	Manufacturing Industries and Construction - Biomass - solid	CH_4		
#35	1.A.1	Energy Industries - Biomass - solid	N_2O		
#37	1.A.1	Energy Industries - Biomass - solid	CH_4		
#38	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	N_2O		
#39	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CH_4		
#40	1.A.3.e	Other Transportation - Liquid Fuels	CO_2		
#41	1.A.4	Other Sectors - Liquid Fuels	CH_4		
#44	1.A.4	Other Sectors - Liquid Fuels	N_2O		
#45	1.A.3.a	Civil Aviation - Liquid Fuels	N_2O		
#46	1.A.3.e	Other Transportation - Liquid Fuels	N_2O		
#47	1.A.3.a	Civil Aviation - Liquid Fuels	CH_4		
#48	1.A.3.e	Other Transportation - Liquid Fuels	CH_4		

Note1: Ap1-L: Approach 1-Level Assessment, Ap1-T: Approach 1-Trend Assessment
Note2: Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

3.1.2. Energy Emission by Gases, 2020 to 2022

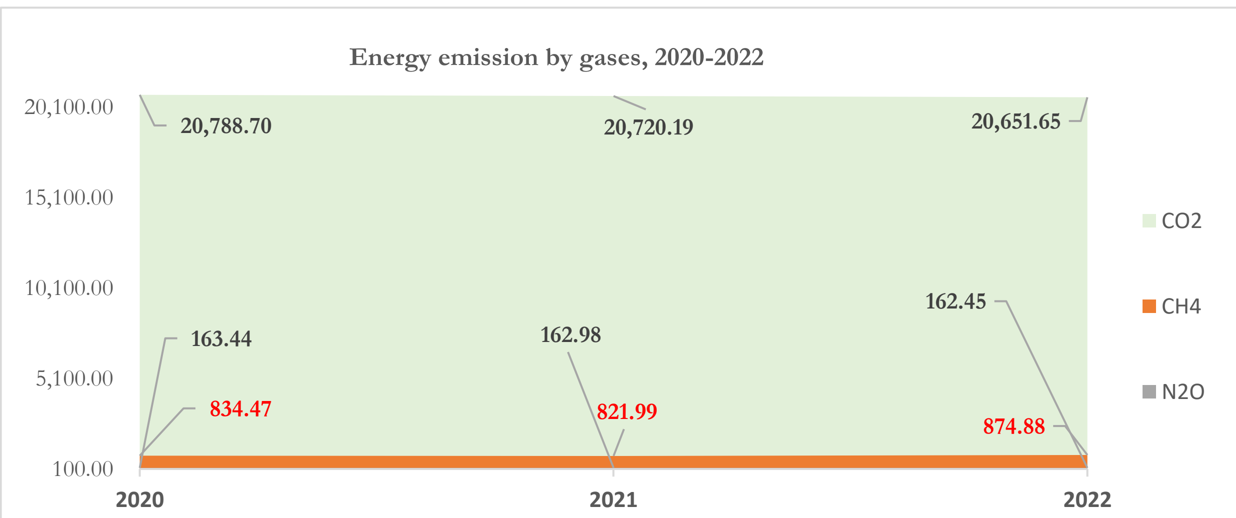


Figure 13 : Energy Emission by Gases, 2020 - 2022

Table 20 : Total CO2 Emission from the Energy Sector (Source Categories)

Greenhouse Gas Source Categories	2020	2021	2022
1. Energy	**20,788.70**	**20,720.18**	**20,651.65**
1.A. Fuel combustion	20,788.70	20,720.18	20,651.65
1.A.1. Energy industries	17,623.09	17,220.30	16,817.41
1.A.2. Manufacturing industries and construction	639.19	924.04	1,208.90
1.A.3. Transport	2,448.06	2,497.35	2,546.72
1.A.4. Other sectors	78.37	78.49	78.62
1.B. Fugitive emissions from fuels	NA,NO	NA,NO	NA,NO

1.B.1. Solid fuels	NA,NO	NA,NO	NA,NO
1.B.2. Oil and natural gas and other emissions from energy production	NO	NO	NO
1.C. CO_2 Transport and storage	NO	NO	NO

Table 21: Total CH4 Emission from Energy Sector (Source Categories)

Greenhouse Gas Source Categories	2020	2021	2022
1. Energy	834.47	821.99	874.88
1.A. Fuel combustion	476.29	472.84	469.33
1.A.1. Energy industries	5.64	5.42	5.14
1.A.2. Manufacturing industries and construction	3.45	4.21	4.97
1.A.3. Transport	9.03	9.22	9.40
1.A.4. Other sectors	458.17	453.99	449.82
1.B. Fugitive emissions from fuels	358.18	349.15	405.55
1.B.1. Solid fuels	358.18	349.15	405.55

Table 22 : Total N2O emission from the Energy Sector (Source Categories)

Greenhouse Gas Source Categories	2020	2021	2022
1. Energy	163.44	162.98	162.45
1.A. Fuel combustion	163.44	162.98	162.45
1.A.1. Energy industries	70.31	68.59	66.79
1.A.2. Manufacturing industries and construction	4.67	5.77	6.87
1.A.3. Transport	33.25	33.92	34.59
1.A.4. Other sectors	55.20	54.71	54.21

3.2. Fuel Combustion (1.A)

3.2.1. Comparison of the Sectoral Approach with the Reference Approach

Due to the lack of data availability (supply data), the reference approach was not conducted

3.2.2. International Bunker Fuels

a). Category Description

International bunkers' emissions were reported separately as Memo Items from the total GHG emissions. This category will report emissions of CO_2, CH_4, and N_2O emitted by international aviation from different types of Aircraft operating in Laos, based on the International Civil Aviation Organization (ICAO), such as A320 and AT72.

b). Methodology Issues

The CO_2, CH_4, and N_2O emissions from this source are derived by multiplying the fuel consumption presented by the ICAO website by the default emission factor.

c). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

d). Emission Factor

The default values given in the 2006 IPCC Guidelines are used for CO_2, CH_4, and N_2O emission factors

Table 23: Emission Factors for CO_2, CH_4 and N_2O from **international bunkers**

	CO_2 Emission Factor	Non- CO_2 Emission Factor [6]	
	CO_2	CH_4	N_2O
Fuel type	Default (Kg/TJ)	Default (Kg/TJ)	Default (Kg/TJ)
Jet Kerosene	71500 [1]		
All fuels		0.5	2

e). Activity data

The activity data for this section is based on the ICAO website reported by the Aviation Department, Ministry of Public Works and Transport of Laos, where the data presented in total yearly CO_2 emission, and it was calculated back for this AD in Terajoule (TJ). The fuel type used for international bunkers is Jet Kerosene.

f). Emission Result from International Bucker

Table 24: Emission Result from International Bucker

Emissions from International Aviation		Gases	2020	2021	2022
			Gg		
1.A.3.a.i	International Aviation	CO_2	15.7658	5.5448	24.0083
1.A.3.a.i	International Aviation	CH_4	0.0001	0.0000	0.0002
1.A.3.a.i	International Aviation	N_2O	0.0004	0.0002	0.0007

3.2.3. Energy Industry (1.A.1)

The Energy industry comprises emissions from fuels combusted by the fuel extraction or energy-producing industries. The main activities include Electricity and Heat Production (Electricity generation, Combined heat and Power generation, Heat plants), Manufacture of Solid Fuels and Other Energy Industries (Manufacture of Solid Fuels and Other Energy Industries).

3.2.3.1. Methodological Issues

a). Choice of Methods

As the Lao PDR did not have country-specific emission factors for the source category and fuel for each gas and combustion technology, a Tier 1 approach was applied to estimate the GHG emissions for Energy Industries (IPCC Guideline 2006, Equation 2.1, Page 2.11, Volume 2, Chapter 2).

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

The AD for Energy Industries is mainly based on Electricity Generation from Hongsa Thermal Power Plant under the 1.A.1.a.i. The types of fuel combustion in the energy industry include solid fuel (Lignite) and another solid biomass. Due to the limited data from internal sources, the ADs for

[6] Non-CO_2 Emission Factor

- CH4 (2006 IPCC Guidelines Vol. 2, Table 3.6.4)
- N_2O (2006 IPCC Guidelines Vol. 2, Table 3.6.5)

2020 and 2021 for Other Solid Biomass were taken from the International Energy Agency (IEA) website, while 2022 data was estimated from biomass power generation per year and the quantity of biomass used. The AD for lignite consumption for the years 2018 and 2022 was provided by the Department of Planning and Finance, Ministry of Energy and Mine, while the Interpolation formula estimated the data for 2019-2021. Other sub-categories cannot be estimated the GHG emissions as the activity data was not available. The detail is shown in (Table 25).

Table 25 : Fuel consumption to estimate GHG emission from Electricity Generation for 2022

No	Activity Data	Fuel Type	Fuel consumption (TJ)	2020	2021	2022	Remark
1	Electricity Generation (1.A.1.a.i)	Solid Fuels	Lignite consumption [7]	174,486	170,498	166,509	Yes
		Biomass-Others	Primary Solid Biomass [8]	900	769	568.30	Yes
2	Combined Heat and Power Generation (1.A.1.a.ii)						NO
3	Heat Plants (1.A.1.a.iii)	-	-	-	-	-	NO
4	Petroleum Refining (1.A.1.b)	-	-	-	-	-	NO
5	Manufacture of Solid Fuels (1.A.1.c.i)	-	-	-	-	-	NO
6	Other Energy Industries (1.A.1.c.ii)	-	-	-	-	-	NO

d). Emission Factor

As Lao PDR did not have country-specific EFs for Electricity Generation, the default value is in the 2006 IPCC Guidelines, Table 2.2, Pages 2.16–2.17, Volume 2, Chapter II. The details are presented in (Table 26).

Table 26: EFs for Estimating GHG Emissions from Electricity Generation

No	Fuel Combustion Emission Factor	Default Emission Factor			
		(Unit)	CO_2	CH_4	N_2O
1	Lignite consumption	TJ	101000	1	1,5
2	Primary Solid Biomass	TJ	100 000	30	4

3.2.4. Manufacturing Industries and Construction (1.A.2)

a). Methodology

As the Lao PDR did not have country-specific emission factors for the source category and fuel for each gas and combustion technology, a Tier 1 approach was applied to estimate the GHG

[7] The lignite consumption data for 2018 and 2022 were provided by the Department of Planning and Finance, Ministry of Energy and Mining, while the data for 2019 and 2021were estimated by applying an interpolation formula.

[8] The primary solid biomass data was taken from the Energy balance data dated 9.10.24 from (better to specify and when you downloaded) International Energy Agency (IEA) website

emissions for Energy Industries (2006 IPCC Guidelines, Equation 2.1, Page 2.11, Volume 2, Chapter 2).

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

The AD for Manufacturing Industries and Construction comprises Iron and Steel, Non-Ferrous Metals, Chemicals, Pulp, Paper and Print, Food Processing, Beverages and Tobacco, Non-Metallic Minerals, Non-Metallic Minerals, Machinery, Mining (excluding fuels), and Quarrying, Wood and Wood Products, Construction, Textile and Leather, and Non-Specified Industry. The fuel combustion used in the Manufacturing Industries and Construction included anthracite, lignite, fuel wood, and oil production (diesel oil and residual fuel oil). However, since no fuel consumption data is available from local sources, the figures on the International Energy Agency (IEA) website were used. However, as the fuel consumption data is not disaggregated regarding the fuel consumption quantity per each industry category, the total fuel consumption was placed under non-specified industries. The detail is presented in (Table 27).

Table 27: Fuel Consumption to Estimate GHG Emission from Manufacturing Industries and Construction for 2022

No	Activity Data	Fuel Type	Fuel consumption (TJ)	2020	2021	2022	Remark
1	Iron and Steel (1.A.2.a)	-	-	-	-	-	
2	Non-Ferrous Metals (1.A.2.b)	-	-	-	-	-	
3	Chemical (1.A.2.c)	-	-	-	-	-	
4	Pulp, Paper and Print (1.A.2.d)	-	-	-	-	-	
5	Food Processing, Beverages and Tobacco (1.A.2.e)	-	-	-	-	-	
6	Non-Metallic Minerals (1.A.2.f)	-	-	-	-	-	
7	Non-Metallic Minerals (1.A.2.g)	-	-	-	-	-	
8	Machinery (1.A.2.h)	-	-	-	-	-	
9	Mining (excluding fuels) and Quarrying (1.A.2.i)	-	-	-	-	-	
10	Wood and Wood Products (1.A.2.j)	-	-	-	-	-	
11	Construction (1.A.2.k)	-	-	-	-	-	
12	Textile and Leather (1.A.2.l)	-	-	-	-	-	
13	Non-Specified Industry (1.A.2.m)	Solid Fuels [9]	Anthracite	3,029	5,667	8,305	
			Lignite	1,824	1,862	1,900	
		Biomass [10]	Wood/Wood Waste	2,276	2,262	2,248	

[9] **Solid Fuels**

- The total amount of solid fuels (anthracite and lignite) data for 2020 and 2021 were taken from IEA website while the data for 2022 was calculated by applying extrapolation formula;

[10] **Biomass**

- The total amount of biomass consumption (wood/wood waste) data for 2020 and 2021 was taken from IEA website, while the data for 2022 was calculated by applying extrapolation formula;

		Total Oil Product Consumption (100%) [11]					
		Liquid Fuels	Gas/Diesel Oil (77.9%)	1,637	1,863	2,088	
			Residual Fuel Oil (22.1%)	464	528	593	

d). Emission Factors

As Lao PDR did not have country-specific EFs for Manufacturing Industries and Construction for 2022, the default value is in the 2006 IPCC Guidelines, Table 2.2, Pages 2.16–2.17, Volume 2, Chapter II. The details are presented in (Table 28).

Table 28: EFs for Estimating GHG Emissions of Manufacturing Industries and Construction for 2022

No	Fuel Combustion Emission Factor	Default Emission Factor			
		(Unit)	CO_2	CH_4	N_2O
1	Anthracite	TJ	98,300	10	1.5
2	Lignite	TJ	101000	10	1.5
3	Wood/Wood Waste	TJ	112000	30	4
4	Residual Fuel Oil	TJ	77400	3	0.6
	Gas/Diesel Oil	TJ	74100	3	0.6

3.2.5. Transport (1.A.3)

The Transport sector resulting in the release of GHG emissions comprises fuel combustion from Civil Aviation (International Aviation (1. A.3. a. i), Domestic Aviation (1.A.3.a.ii), Road Transportation (Cars, Light-duty trucks, Heavy-duty trucks and buses, and Motorcycles, Evaporative emission from vehicles, Urea-based catalysts), Railways, Water-borne Navigation (International water-born navigation, and Domestic water-born navigation), and Other Transportation (Pipeline transport and Off-road)

a). Choice of Methodology

To estimate the GHG emissions from international and domestic aviation in Lao PDR, the Tier 1 method was applied (2006 IPCC Guidelines, Equation 3.6.1, Chapter III, Volume 2, Page 3.58)

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

[11] **Total Oil Product Consumption**

- The total consumption of Oil Products (Gas/Diesel Oil and Residual Fuel Oil) was taken from IEA website, while the data for 2022 was calculated by applying extrapolation formula.
- The ratio of fuels type aggregation based on energy demand and supply of the Lao PDR 2010-2018, Appendix 1: Energy Balance Table of the Lao PDR 2010 – 2018, Page 20: Website: https://www.eria.org/research/energy-demand-and-supply-of-the-lao-peoples-democratic-republic-2010-2018

c). Activity Data (AD)

The AD for the transport sector in Laos is from fuel combustion from International Aviation, Domestic Aviation, Road transportation, and other Transportation. The types of fuel combusted in those activities are Jet Kerosene, motor gasoline, Deiseal Oil, and Lubricant.

Data sources for international aviation and other Transportation are provided by the Department of Civil Aviation and Ministry of Public Work and Transport, while data for domestic aviation and road transportation since no local data is available, were taken from the IEA website. As no disaggregated activity data by vehicle type is available for road transport, the emissions from road transport are reported under the Car. The detail is presented in (Table 29).

As figures shown in the table 29 below, the effect of COVID-19 has noticeably impacted international aviation. However, this is not clearly seen in the domestic aviation and road transportation. This is due to the restriction measures domestically being less stringent compared to those applied to international transport.

Table 29: Fuel Consumption to Estimate GHG Emission from Transport for 2022

No	Activity Data	Fuel Type	Fuel consumption (TJ)	2020	2021	2022	Remark
1	International Aviation (1. A.3.a.i) [12]	Liquid Fuels	Jet Kerosene	220.50	77.55	335.78	Yes
2	Total fuel consumption for domestic aviation and cars (100%) [13]			33,468	34,143	34,818	Yes
2.1	Domestic Aviation[14] (1. A.3.a. ii	Liquid Fuels	Jet Kerosene (0.4%)	134	137	139	Yes
2.2	Cars[15] (1. A.3.b.i)	Liquid Fuels	Diesel oil (79.6%)	6,627	6,760	6,894	Yes
		Liquid Fuels	Motor gasoline (19.8%)	26,641	27,178	27,715	Yes
		Liquid Fuels	Lubricant (0.2%)	67	68	70	Yes
3	Light-duty trucks (1. A.3.b.i)	-	-	-	-	-	IE
4	Heavy-duty trucks and buses (1. A.3.b.iii)	-	-	-	-	-	IE
5	Motorcycles (1. A.3.b.iv)	-	-	-	-	-	IE
6	Evaporative emission from vehicles (1. A.3.b.v)	-	-	-	-	-	NO

[12] **International Aviation**

- The fuel consumption data of the international aviation for 2020, 2021, and 2022 was obtained from Department of Civil Aviation, Ministry of Public Work and Transport.

[13] **Domestic Aviation and Cars**

The data available on the IEA website is total fuel consumption for the "Transport" only, which cannot be used under IPCC guidelines that require at least disaggregated activity data among the types of transport. Thus, to use this data, the Energy Balance Table (EBT) from the Energy Demand and Supply of the Lao PDR 2010 – 2018, Appendix 1, page 20 Website: https://www.eria.org/research/energy-demand-and-supply-of-the-lao-peoples-democratic-republic-2010-2018 was used as a reference to calculate the ratio of fuel and fuel type consumption between Domestic aviation (Jet kerosene) and Road transportation (Diesel oil, Motor gasoline, and Lubricant). Based on the Lao EBT, between 2010 and 2018, domestic aviation used only 0.4% of total fuel consumption for transport, while road transportation covered 0.96% (Diesel oil 79.6% , motor gasoline 19.8%, and Lubricant 0.2%).

[14] Domestic Aviation

- The total fuel consumption data of the domestic aviation for 2020 and 2021 were obtained from IEA website while the fuel consumption data for 2022 was calculated by applying Extrapolation formula.

[15] **Car**

- The total fuel consumption data of the Road transportation for 2020 and 2021 were obtained from IEA website while the fuel consumption data for 2022 was calculated by applying Extrapolation formula

7	Urea-based catalysts (1. A.3.b.vi)	-	-	-	-	-	NO
8	Railways (1.A.3.c)	-	-	-	-	-	NE
9	Water-borne Navigation (1.A.3.d)	-	-	-	-	-	NE
10	Pipeline Transport (1.A.3.e.i)	-	-	-	-	-	NO
11	Off-Road (1.A.3.e.ii)[16]	Liquid Fuels	Diesel oil	2.92	2.92	2.92	Yes

d). Emission Factor

As Lao PDR did not have country-specific EFs for Manufacturing Industries and Construction for 2022, the default value is in the 2006 IPCC Guidelines, Table 2.2, Pages 2.16–2.17, Volume 2, Chapter II. The details are presented in (Table 30).

Table 30: EFs for Manufacturing Industries and Construction for 2022

No	Fuel Combustion Emission Factor	Default Emission Factor			
		(Unit)	CO2	CH4	N2O
1	Jet Kerosene	TJ	71, 500	0.5	2
2	Diesel oil	TJ	74,100	3.9	3.9
3	Motor gasoline	TJ	73,300	3	0.6
4	Lubricant	TJ	69,300	33	3.2

3.2.6. Other Sectors (1.A.4)

a). Methodology

- Tier 1 approach method was applied to estimate the GHGs emissions from commercial, institutional, residential, and Off-road vehicles and other Machines (2006 IPCC Guidelines, Chapter 2, Volume 2, Equation 2.1, Page 2.11).

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

The AD for the Other Sector comprises Commercial/Institutional, Residential, Stationary, and Off-road Vehicles and other Machines. The fuel combustion used for the Other Sectors included Liquefied Petroleum Gas (LPG), Biofuels and Waste Consumption (Wood/Wood waste and Charcoal), and Gas/Diesel. The detail is presented in (Table 31).

[16] **Off-Road**

- The fuel consumption data of the Off-road for 2020, 2021, and 2022 was obtained from Department of Civil Aviation, Ministry of Public Work and Transport.

Table 31: Fuel Consumption to Estimate GHG Emission from Other Sector for 2022

No	Activity Data	Fuel Type	Fuel Consumption (TJ)	2020	2021	2022	Remark
1	Commercial/Institutional (1.A.4.a) **17**	Liquid Fuels	Liquefied Petroleum Gas (LPG	745	746	747	Yes
		Biomass-solid	Wood/wood waste + Charcoal (100%)	11,310	11,316	11,322	Yes
			Wood/Wood waste (97%)	10,970.70	10,976.52	10,982.34	Yes
			Charcoal (3%)	339.30	339.48	339.66	Yes
2	Residential (1.A.4.b)**18**	Liquid Fuels	Liquefied Petroleum Gas (LPG	484.00	485.00	486.00	Yes
		Biomass-solid	Wood/wood waste + Charcoal (100%)	45,256.00	44,731.00	44,206.00	Yes
			Wood/Wood waste (87%)	39,466.33	39,008.49	38,550.66	Yes
			Charcoal (13%)	5,789.67	5,722.51	5,655.34	Yes
3	Off-Road Vehicles and Other Machinery (1.A.4.c.ii) **19**	Liquid Fuels	Gas/Diesel	11	11	11	Yes

[17] **Commercial/Institutional**

- The fuel consumption data of the Liquefied Petroleum Gas (LPG) for 2020 and 2021 was obtained from IEA website while the fuel consumption data for 2022 was calculated by applying extrapolation formular;
- The total amount of wood/wood waste and charcoal for 2020 and 2021 were obtained from IEA website; while the data for 2022 was calculated by applying extrapolation.
- The aggregated fuel consumption data ratio of the wood/wood waste and charcoal for 2020 and 2021 were calculated based on the ratio value from **source:** Lao PDR Energy Statistics 2018, Table 1.12, Department of Energy and Planning, Ministry of Energy and Mines, Lao PDR and data from 2022 was calculated by applying extrapolation.

[18] **Residential**

- The fuel consumption data of the Liquefied Petroleum Gas (LPG) for 2020 and 2021 was obtained from IEA website while the fuel consumption data for 2022 was calculated by applying extrapolation formular;
- The total amount of wood/wood waste and charcoal for 2020 and 2021 were obtained from IEA website; while the data for 2022 was calculated by applying extrapolation.
- The aggregated fuel consumption data ratio of the wood/wood waste and charcoal for 2020 and 2021 were calculated based on the ratio value from **source:** Lao PDR Energy Statistics 2018, Table 1.12, Department of Energy and Planning, Ministry of Energy and Mines, Lao PDR and data from 2022 was calculated by applying extrapolation formular.

[19] **Off-Road Vehicles and Other Machinery**

- The fuel consumption data for the Diesel oil for 2020 – 20221 was obtained from IEA website while the fuel consumption data for 2022 was calculated by applying extrapolation formular.

d). Emissions Factors

As Lao PDR did not have country-specific EFs for Other Sectors, the default value is in the 2006 IPCC Guidelines, Table 2.4, Pages 2.20 – 2.21, Volume 2, Chapter II. The details are presented in (Table 32).

Table 32: The Emission Factor for Estimating GHG Emission from Other Sector for 2022

No	Fuel Combustion Emission Factor	Default Emission Factor			
		(Unit)	CO_2	CH_4	N_2O
1	Liquefied Petroleum Gas (LPG)	TJ	61,100	5	0.1
2	Wood/Wood waste	TJ	112,000	300	4
3	Charcoal	TJ	112,000	200	1
4	Gas/Diesel	TJ	74100	10	0.6

3.3. Fugitive Emission from Fuels (1.B)

All intentional and unintentional emissions from the extraction, processing, storage, and transport of fuel to the point of final use release greenhouse gas emissions. Three types of mines need to be accounted for in estimating emissions: Underground Mines, Surface Coal Mines, and Abandoned Surface Mines (2006 IPCC Guidelines, Chapter IV, Volume 2, Page 4.6).

3.3.1. Solid Fuels (1.B.1)

a). Methodology

The Tier 1 approach and Equation 4.1.8 formula were used to estimate the CH_4 and CO_2 emission from Surface Coal Mining (2006 IPCC Guidelines, Chapter IV, Volume 2, Page 4.19)

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

There is only Surface mines activity available in Lao PDR. The detail is presented in (Table 33).

Table 33: Activity for Fugitive emission for 2022

No	Activity Data	Fuel Type	Amount of Coal produced (Tonne)			Remark
			2020	2021	2022	
1	**Underground mines**					NO
	Mining (1.B.1.a.i.1)	Coal	-	-	-	NO
	post-mining seam gas emission (1.B.1.a.i.2)	Coal	-	-	-	NO
	abandoned underground mines (1.B.1.a.i.3)	Coal	-	-	-	NO
	flaring of drained methane or conversion of methane to CO_2 (1.B.1.a.i.4)	Coal	-	-	-	NO
2	**Surface mines**	Coal	-	-	-	Yes

	Mining (1.B.1.a.ii.1) [20]	Coal	14,686,859	14,316,593	16,629,134	Yes
	post-mining seam gas emission (1.B.1.a.ii.2)	Coal	14,686,859	14,316,593	16,629,134	Yes
3	**Uncontrolled combustion and burning coal dumps (1.B.1.b)**	Coal	-	-	-	NO

d). Emission Factor

Due to the lack of data on overburdened depth as it is reported to be confidential data from the sector in charge, according to 2006 IPCC Guideline, Chapter IV, Volume 2, Page 4.18 and 4.19, the average emission factor, namely 1.2 m3/tonne has been used

[20] The amount of coal produce was obtained for 2020, 2021, and 2022 from Lao SIS Statistical Years Book, Lao Statistic Bureau, Ministry of Planning and Investment (MPI)

CHAPTER IV. INDUSTRIAL PROCESS AND PRODUCT USE (IPPU)

4.1. Overview of the IPPU Sector

The greenhouse gas (GHG) emissions in the IPPU sector include CO_2 and HFCs. These emissions were estimated from Cement production, Lime production, Iron and Steel Production, Lubricant use, Paraffin Use, Refrigeration and Stationary Air Conditioning, and Mobile Air Conditioning. The largest gas emitted was CO_2, accounting for 5,026.52 (Gg CO_2 eq), and followed by HFCs emissions at 200.02 (Gg CO_2 eq). The GHG emissions in the IPPU sector for 2022 are presented in (Table 34).

Table 34: GHG Emissions from the Energy Sector for 2022

Categories 2022	Global Warming Potential_ AR5 Emission (GgCO2 eq)				Total
	CO_2	CH_4	N_2O	HFCs	
2. Industrial processes and product use	**5,026.52**	NA, NO	NA, NO	200.02	**5,226.55**
2.A. Mineral industry	5,022.20				5,022.20
2.B. Chemical industry	NO	NO	NO	NO	0.00
2.C. Metal industry	4.16	NA, NO	NO	NO	4.16
2.D. Non-energy products from fuels and solvent use	0.16	NA, NO	NA, NO		0.16
2.E. Electronic Industry			NO	NO	0.00
2.F. Product uses as ODS substitutes				200.02	200.02
2.G. Other product manufacture and use	NO	NO	NO	NO	0.00
2.H. Other	NO	NO	NO	NO	0.00

Table 35: Methodology used in the IPPU Sector

Categories	CO_2		HFCs	
2.A.1 - Cement production	T1	D	T1	D
2.A.2 - Lime production	T1	D	T1	D
2.C.1 - Iron and Steel Production	T1	D	T1	D
2.D.1 - Lubricant Use	T1	D	T1	D
2.D.2 - Paraffin Wax Use	T1	D	T1	D
2.F.1.a - Refrigeration and Stationary Air Conditioning	T1	D	T1	D
2.F.1.b - Mobile Air Conditioning	T1	D	T1	D

Note: D: IPCC default value, T1: Tier 1 approach

4.1.1. Key Categories of IPPU Sector

Table 36 : Key Categories of IPPU (Including LULUCF)

No	A Code	B Category	C GHGs	AP1-L 2022	AP1-T 2020-2022
#5	2.A.1	Cement production	CO_2	#5	#7
#23	2.F.1	Refrigeration and Air Conditioning	HFCs		
#36	2.A.2	Lime production	CO_2		
#38	2.C.1	Iron and Steel Production	CO_2		
#52	2.D	Non-Energy Products from Fuels and Solvent Use	CO_2		

Note 1: Ap1-L: Approach 1-Level Assessment, Ap1-T: Approach 1-Trend Assessment,
Note 2: Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

Table 37: Key Categories of IPPU (Excluding LULUCF)

No	A Code	B Category	C GHGs	AP1-L	AP1-T
#2	2.A.1	Cement production	CO_2	#2	#1
#16	2.F.1	Refrigeration and Air Conditioning	HFCs		
#28	2.A.2	Lime production	CO_2		
#30	2.C.1	Iron and Steel Production	CO_2		
#43	2.D	Non-Energy Products from Fuels and Solvent Use	CO_2		

Note 1: Ap1-L: Approach 1-Level Assessment, Ap1-T: Approach 1-Trend Assessment,
Note 2: Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

4.1.2. IPPU Emission by Sub-Categories, 2020 to 2022

(Figure 14) presents that the largest sub-categories sources for 2020, 2021, and 2022 are mineral industry, covering 2,424.35 ($GgCO_2eq$), 5,659.96 ($GgCO_2eq$), and 5,022.20 ($GgCO_2eq$), respectively, followed by Product uses as substitutes for ODS for 2020, 2021, and 2022, which were 171.14 (GgCO2eq), 185.71(GgCO2 eq), and 200.02 (GgCO2 eq), while the lowest sub-categories sources were Non-energy products from fuels and solvent use , covering 0.53 (GgCO2 eq), 0.11(GgCO2 eq), and 0.16 (GgCO2 eq) for 2020, 2021, and 2022, respectively.

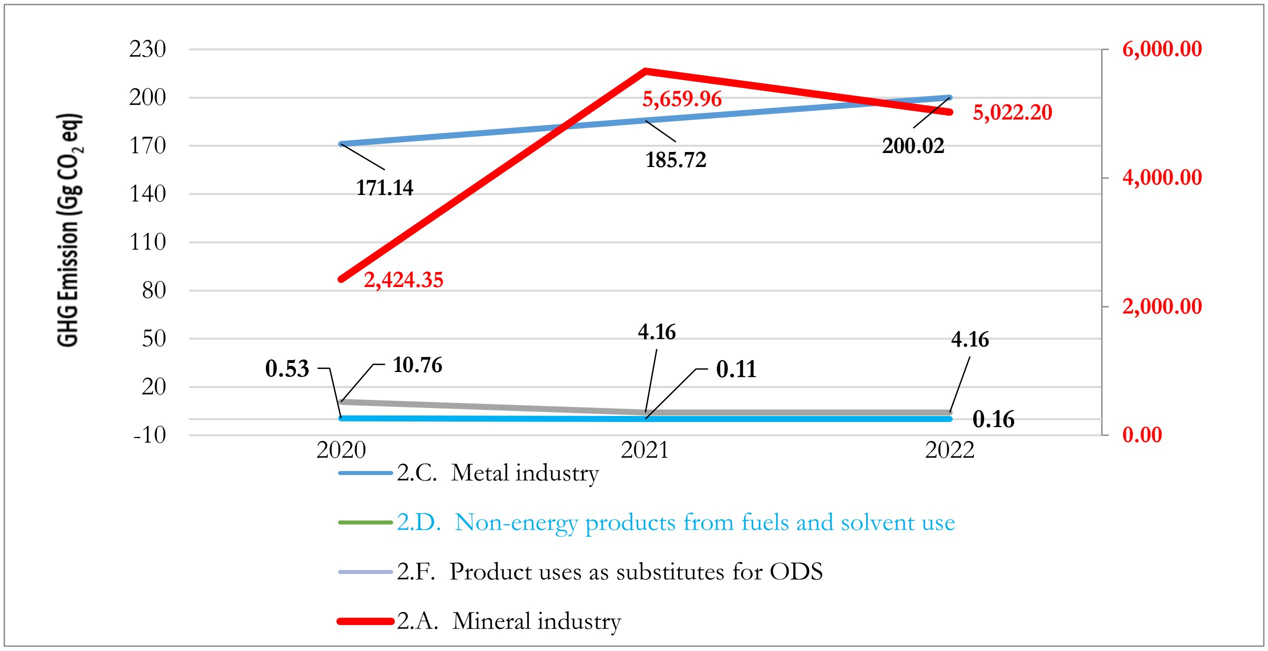


Figure 14: GHGs Emission of Sub-Categories from IPPU sector, 2020-2022

Table 38: GHG Emission of Sub-Categories from IPPU sector, 2020 – 2022

Sub-categories	2020	2021	2022
2. Industrial processes and product use	**2,606.78**	**5,849.95**	**5,226.55**
2.A. Mineral industry	2,424.35	5,659.96	5,022.20
2.C. Metal industry	10.76	4.16	4.16
2.D. Non-energy products from fuels and solvent use	0.53	0.11	0.16
2.F. Product uses as substitutes for ODS	171.14	185.72	200.02

4.2. Mineral Industry (2.A)

4.2.1. Cement Production (2.A.1)

CO_2 is produced during the production of clinker in cement manufacturing. During clinker production, limestone, mainly calcium carbonate (CaCO3), is heated or calcined to produce lime (CaO) and CO_2 as a by-product. The clinker minerals resulted from a CaO reaction with silica (SiO2), alumina (AL2O3), and iron oxide (Fe2O3) in the raw materials (IPCC Guideline 2026, Chapter 2, V 3, Page 2.7)

a). Methodology

- The Tier 1 approach was applied to estimate the GHG emissions in the Cement Production 2006 IPCC Guidelines, Equation 2.1, Volume 3, Chapter 2, Page 2.8)

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

The AD for cement production comprises cement production, clinker import, and clinker export. The data was from the Lao Statistical Information Service (LAOSIS), the Ministry of Investment and Planning, the Department of Foreign Trade, and the Ministry of Industry and Commerce. The detail is presented in (Table 39).

Table 39: Cement Production and Import and Export of Clinker [21]

Production	Unit	Individual Type of Cement Produced	2000	2021	2022
Cement	tonne	Unspecified	6,162,000	14,412,000	12,800,000
Clinker import	tonne		11,038	4,194	3,605
Clinker export	tonne		38,894	63,428	44,778

[21] **Cement Production**

- The Cement production for 2020, 2021, and 2022 was obtained from Lao Statistical Information Service (LAOSIS), Ministry of Investment and Planning https://laosis.lsb.gov.la/tblInfo/TblInfoList.do;jsessionid=XHvyQStSI-29K1-BKKagbCRE5mv3rWPDHMBQtyZJ.laosis-web

Clinker Import and Export

- The clinker import and export for 2020, 2021, and 2022 was obtained Department of Foreign Trade, Ministry of Industry and Commerce https://laotradestat.moic.gov.la/estat/search/yearly?

d). Emission Factor and Fraction

- Since the Lao PDR did not have the country-specific of EFs, the emission factor for clinker was obtained from IPCC 2006, Equation 2.4, Volume 3, Chapter 2, Page 2.12 with the value of 0.52 tonnes CO_2/tonne Clinker;
- The emission factor for clinker corrected for CKD was 1.02 tonnes CO_2/tonne clinker (2006 IPCC Guidelines, Equation 2.4, Volume 3, Chapter 2, Page 2.12);
- The Clinker production in Cement was 0.75 (2006 IPCC Guidelines, Volume 3, Chapter 2, Page 2.13).

4.2.2. Lime Production (2.A.2)

Heating limestone to decompose the carbonates caused the calcium oxide (CaO or quicklime) and the process shaft or rotary at high temperatures to produce CO_2. Dolomite and dolomitic (high magnesium) limestones may also be processed at high temperatures to produce dolomitic lime and release CO_2. Lime production includes several activities such as quarrying of raw materials, crushing and sizing, calcining the raw material to produce lime, and hydrating the lime to calcium hydroxide (2006 IPCC Guidelines, Chapter 2, V 3, Page 2.19).

a). Methodology

- Since Lao PDR did not have country-specific information on lime production by type such as high calcium lime, dolomitic lime, or hydraulic lime, the Tier 1 approach was applied for estimation of CO_2 emissions from lime production.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

The AD for Lime Production comprises a mass of lime produced (tonne). The data for 2022 was taken from the Statistical Yearbook Energy and Mines 2022, Department of Planning and Cooperation, Ministry of Energy and Mines, and data for 2015 backward were extracted from Statistical Yearbook 2015, Lao Statistics Bureau, Ministry of Planning and Investment while the data for 2019 and 2021 was calculated by applying the Interpolation formula using the data of 2015 and 2022a. The detail is presented in (Table 40).

Table 40: The Lime Production to Estimate the GHG Emissions for 2022 [22]

Production	Unit	Type of Lime Produced	2000	2021	2022
Lime Production	tonne	All lime production	7,671.43	8,410.71	9,150.0

[22] **Lime Production**

- The total amount of Lime Production data for 2022 was taken from Lao Statistical Information Service (LAOSIS), Ministry of Investment and Planning and Department of Foreign Trade, Ministry of Industry and Commerce while the data for 2020 and 2021 was calculated by applying extrapolation formula;

d). Emission Factor

- Tire 1 default emission factor with the value 0.75 tonnes CO_2 was applied for estimation of CO_2 emissions from lime production (2006 IPCC Guidelines, Equation 2.8, Chapter 2, Page 2.22).

4.3. Chemical Production (2.B)

The GHG emissions from Chemical Production comprise Ammonia Production, Nitric Acid Production, Adipic Acid Production, Caprolactam, Glyoxal and Glyoxylic Acid Production, Carbide Production, Titanium Dioxide Production, Soda Ash Production, Petrochemical and Carbon Black Production, and Fluorochemical Production.

According to the Department of Industry, Ministry of Industry and Commerce (MOIC), there are currently eight chemical factories in Lao PDR. However, from the list of chemical industries, there is no emission associated with emission sources of GHGs. Thus, the emission source from this category is considered never to occur in Laos.

4.4. Metal Industry (2.C)

Activities resulting in GHG emissions in the Metal Industry include Iron and Steel Production, ferroalloy production, Aluminum Production, Magnesium production, Lead production, and Zinc Production. In Laos, there is only an emission source from Iron and Steel Production where the production process leads to GHG emissions of carbon dioxide (CO_2), Methane (CH_4), and nitrous oxide (N_2O)

a). Methodology

- Tier 1 approach was applied for estimating CO_2 Emissions from Iron and Steel production (2006 IPCC Guidelines, Chapter IV, Volume 3, Equation 4.4, Page 4.21);
- The steel and Iron-making method in Laos is reported by sector in charge to be produced from iron scrap only (Secondary facilities). This means that the steel and iron-making method is by electric arc furnace (EAF).

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

The GHG emissions released from the Metal Industry were only from Iron and Steel Production, where factories reported producing Steer bars and Rods of Iron from iron scrap (Secondary facilities) only. The needed data was taken from the Statistical Yearbook of 2021 and 2022, Lao Statistics Bureau, Ministry of Planning and Investment. The detail is presented in (Table 41). As shown in the table, there is a sharp decline in iron and steel production in the country between 2021 and 2022. According to data providers from LAOSIS, the trend of iron and steel consumption shows that consumption steadily increased from 2014 to 2019 as a pick, and the trend started to decline between 2019 and 2021 at the lowest level. However, the trend started to increase again from 2022 to 2023. This is assumed to be an effect of COVID-19 hitting the country where construction activities dropped, resulting in the decline of this product's consumption.

Table 41: The Iron and Steel Production to Estimate the GHG Emissions for 2022

Production		Unit	Type of Steelmaking Method, etc.	2000	2021	2022
Iron and Steel Production (2.C.1)	Steel bars (Construction)	tonne		76,359	29,512	29,513
	Rod of Iron	tonne		58,168	22,482	22,504
	Total (Steel + Iron)	tonne	Electric Arc Furnace (EAF)	**134,527**	**51,994**	**52,017**
Ferroalloys Production (2.C.2)	-	tonne	-	-	-	-
Aluminium Production (2.C.3)	-	tonne	-	-	-	-
Magnesium Production (2.C.4)	-	tonne	-	-	-	-
Lead Production (2.C.5)	-	tonne	-	-	-	-
Zine Production (2.C.6)	-	tonne	-	-	-	-

d). Emission Factor

- The emission factor for estimating CO_2 from Iron and Steel production was 0.08 tonne CO_2/tonne produced (2006 IPCC Guidelines, Chapter IV, Volume 3, Table 4.1, Page 4.25).

4.5. Non-Energy Production from Fuels and Solvent Use (2.D)

a). Methodology

- The products in the Non-Energy Production from Fuels and Solvent Use comprises lubricants, paraffin waxes, bitumen/asphalt, and solvents;
- The methods for calculating carbon dioxide (CO_2) emission from Non-Energy Production from Fuels and Solvent Use was applied the Equation 5.1 (2006 IPCC Guidelines, Chapter V, Volume 3, Page 5.5);
- To estimate the CO_2 emission from Lubricants use was applied the Equation 5.2 (2006 IPCC Guidelines, Chapter V, Volume 3, Page 5.7);
- To estimate the CO_2 emission from Paraffin wax was applied the Equation 5.4 (2006 IPCC Guidelines, Chapter V, Volume 3, Page 5.11).

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

The AD for estimating GHG emissions in Non-Energy Production from Fuels and Solvent Use comprise Lubricant Use, Paraffin Wax Use, Solvent Use, and Others. However, there were only Lubricant Use and Paraffin Wax Use activities available in Lao PDR. The detail is presented in (Table 42) and (Table 43).

Table 42 :The Lubricant Use to Estimate the GHG Emissions for 2022

Production	Import	Estimation	Unit	2000	2021	2022
Lubricant Use (2.D.1) [23]	Lubricant preparations	A	tonne	241.8	20.7	55.0
	Other Lubricant	B	tonne	195.2	8.8	0.5
	Preparation containing silicone oil	C	tonne	40.9	0.0	0.001
	Preparations for aircraft engines	D	tonne	254.0	25.9	34.1
	Lubricant consumption	E = A+B+C+D	tonne	731.9	55.4	89.6
	Default Net Calorific Value (NCV)	F	TJ/Gg	40.2	40.2	40.2
	Lubricant consumption	**G = E/1000 x F**	**TJ**	**29.4**	**2.2**	**3.6**

Table 43: The Paraffin Wax Use to Estimate the GHG Emission for 2022

Production	Import	Estimation	Unit	2000	2021	2022
Paraffin Wax [24]	Paraffin Wax	A	tonne	114.0	128.0	183.6
	Paraffin Wax, Containing < 0.75% oil	B	tonne	50.0	0.0	0.0
	Paraffin Wax total consumption	C = A+B	tonne	164.0	128.0	183.6
	Default Net Calorific Value (NCV)	D	TJ/Gg	40.2	40.2	40.2
	Paraffin Wax total consumption	**E = C/1000 x D**	**TJ**	**6.6**	**5.1**	**7.4**

d). Emission Factor

- The default carbon contents factor of lubricant type (tonne C/TJ) was 20 kg C/GJ (2006 IPCC Guidelines Guideline, Chapter V, Volume 3, Page 5.9);
- The Oxidised During Use (ODU) factor for lubricant type was 0.2 (2006 IPCC Guidelines, Chapter V, Volume 3, Table 5.2, Page 5.9);
- The carbon content of Paraffin wax (tonne C/TJ) was 20 kg C/GJ (2006 IPCC Guidelines, Chapter V, Volume 3, Page 5.12);
  The Oxidised During Use (ODU) factor for lubricant type was 0.2 (2006 IPCC Guidelines, Chapter V, Volume 3, Table 5.2, Page 5.12);

[23] **Lubricant Use**

- The Total Lubricant Consumption data, including Lubricant Preparations, Other Lubricant, Preparation containing silicone oil, and Preparations for aircraft engines for 2020, 2021, and 2022 was obtained from Lao Trade Statistic System website. https://www.dftp.moic.gov.la/en/trade-statistics/
- The NCV value was taken from 2006 IPCC Guidelines, Chapter 1, Volume 2, Table 1.2, Page 1.18

[24] **Paraffin Wax**

- The total Paraffin Wax consumption data for 2020, 2021, and 2022 was obtained from Lao Trade Statistic System website. https://www.dftp.moic.gov.la/en/trade-statistics/
- The total Paraffin Wax, containing < 0.75% oil for 2020, 2021, and 2022 was obtained from world Integrated Trade Solution website: https://wits.worldbank.org/

4.6. Electronics Industry (2.E)

The GHG emission from the electronics Industry comprise Integrated Circuit or Semiconductor, TFT Flat Panel Display, Photovoltaics', Heat Transfer Fluid, and Other. However, relevant emissions and removals are considered never to occur in Laos

4.7. Production Use as Substitutes for Ozone Depletion Substance (2.F)

HFCs, distinct from ODSs, have emerged as the primary substitutes for ODSs such as HCFCs and CFCs in the past decade due to their advantageous qualities like low or no flammability, chemical stability, relatively modest cost, and exceptional performance as refrigerants, foam-blowing agents, aerosol propellants, or solvents. Recently, the usage of HFCs in Lao PDR has consistently increased as a substitute for ozone-depleting substances (ODS).

HFCs, or hydrofluorocarbons, are widely used in manufacturing and as refrigerants in refrigeration and air conditioning equipment. Laos has no activities related to the manufacturing of refrigeration and air conditioning (RAC) equipment and F-gases. Thus, the emissions of F-gases are only utilized by using these F-gases in servicing sectors.

4.2.7.1. Refrigeration and Air Conditioning and Mobile Air Conditioning

a). Methodology

The method for calculating F gas emissions is based on Tier 1 a/b method for refrigeration and air conditioning, page 7.45, Chapter 7, Volume 3, the 2006 IPCC Guidelines.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

Lao PDR has none of the equipment and substances manufacturing activities exits. Thus, refrigeration and air conditioning (RAC) appliances and substances are imported from neighboring countries. For this report, AD (sales of a specific refrigerant) of each year was estimated by applying the solvent's formula using introduction year data and estimated amounts of existing refrigerants under the assumption that the growth rate of the new sales of each refrigerant is constant. The exception is R-407C, whose sales were estimated to be the same in 2020 and 2021, with no sales in 2022.

Data for the estimation is taken from: 1). HFCs usage in the servicing sector under Kigali HFCs Implementation Plan Stage 1, Lao PDR (for the refrigerant amount information), and 2). large RAC appliance end-user survey results and Lao People's Democratic Republic HCFC phase-out management plan stage II (for the introduction year information). For the cases where the introduction year cannot be obtained directly from the data sources above, their introduction years were supposed with the reasonable assumptions based on the end-user survey results. The detailed AD for 2020-2022 is shown in the table below in the (Table 44).

Table 44: The Activity Data of the Estimated Sales of a Specific Refrigerant in Lao PDR, 2020 – 2022

HFCs		Introduction year	Growth rate (%)	2020	2021	2022
				tones		
1	HFCs -32	2016	11	16.8	18.68	20.77
2	R-410A	2013	4.63	70.01	73.26	76.65
3	R-404A	2013	9.33	5.31	5.8	6.35
4	HFCs -134A (RAC)	2008	0.11	34.13	34.16	34.2
5	HFCs -134A (MAC)	2008	9.07	32.01	34.91	38.07
6	R-407C	2020	0	1.31	1.31	-

d). Emission Factor

The emission factor uses the default emission factor of 15 % as the assumption estimated weighed average across all sub-applications of bank refrigerant, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3: Industrial Processes and Product Use, page 7.51

CHAPTER V: AGRICULTURE SECTOR

5.1. Overview of the Agriculture Sector

GHG emissions and removals in the agriculture sector for the inventory year of 2022 were calculated based on the 2006 IPCC Guidelines. The Agriculture Sector consists of the following categories[25].

a. Emission from Livestock (3A);
b. Burning in Cropland (3.C.1.b)
c. Burning in Grassland (3.C.1.c)
d. Liming (3.C.2)
e. Urea application (3.C.3)
f. Direct N_2O emission from managed soil (3.C.4)
g. Indirect N_2O emission from managed soil (3.C.5)
h. Indirect N_2O emission from manure management (3.C.6)
i. Rice cultivation (3.C.7)

The total GHG emissions from the agriculture sector in 2022 were 10,480.02 (Gg-CO_2 eq), in which the emissions from the Enteric Fermentation are the largest emission, accounting for 3,678.04 (Gg-CO_2 eq), followed by Agricultural soils, account for 3,274.42 (Gg-CO_2 eq), and the lowest was Liming, accounting for 0.53 (Gg-CO_2 eq).

Table 45: The total GHG Emission from Agriculture Sectors (excluding LULUCF) for 2022 (Gg-CO_2eq)

Categories	Global Warming Potential AR5 Emission for 2022 (Gg-CO2eq)			Total
	Net CO2 emissions	CH_4	N_2O	
3. Agriculture	**13.85**	**6,575.16**	**3,891.02**	10,480.02
3.A. Enteric fermentation	0.00	3,678.04		3,678.04
3.B. Manure management	0.00	1,036.33	561.56	1,597.90
3.C. Rice cultivation	0.00	1,754.79		1,754.79
3.D. Agricultural soils	0.00		3,274.43	3,274.43
3.E. Prescribed burning of savannahs	0.00	46.90	40.53	87.43
3.F. Field burning of agricultural residues	0.00	59.09	14.50	73.59
3.G. Liming	0.54	0.00		0.54
3.H. Urea application	13.31	0.00	0.00	13.31
3.I. Other carbon-containing fertilizers		0.00		0.00
3.J. Other				0.00

Table 46: Tier of Methodology used in the agriculture sector [26]

GHG Categories	CO_2		CH_4		N_2O	
3.A.1 - Enteric Fermentation	D	T1	D	T1	D	T1
3.A.2 - Manure Management (1)	D	T1	D	T1	D	T1
3.C.1 - Burning	D	T1	D	T1	D	T1
3.C.2 - Liming	D	T1	D	T1	D	T1
3.C.3 - Urea application	D	T1	D	T1	D	T1
3.C.4 - Direct N_2O Emissions from managed soils (3)	D	T1	D	T1	D	T1
3.C.5 - Indirect N_2O Emissions from managed soils	D	T1	D	T1	D	T1

[25] In this BTR, the category codes according to the 2006 IPCC Guidelines are used.
[26] As lack of data in the country, Tier 1 approach is applied to estimate CO_2 emissions even for key categories in the agriculture sector. Lao PDR intends to make efforts to use higher tiers for key categories in the future BTRs.

3.C.6 - Indirect N_2O Emissions from manure management	D	T1	D	T1	D	T1
3.C.7 - Rice cultivation	D	T1	D	T1	D	T1

Note: D: IPCC default; **T1:** Tier 1 approach

(Figure 15) shows that the agriculture emission from CH_4, N_2O, and CO_2 in 2022 increase 1.65 %, increased 8.10 %, and increased 2.25%, respectively compared to the year 2020.

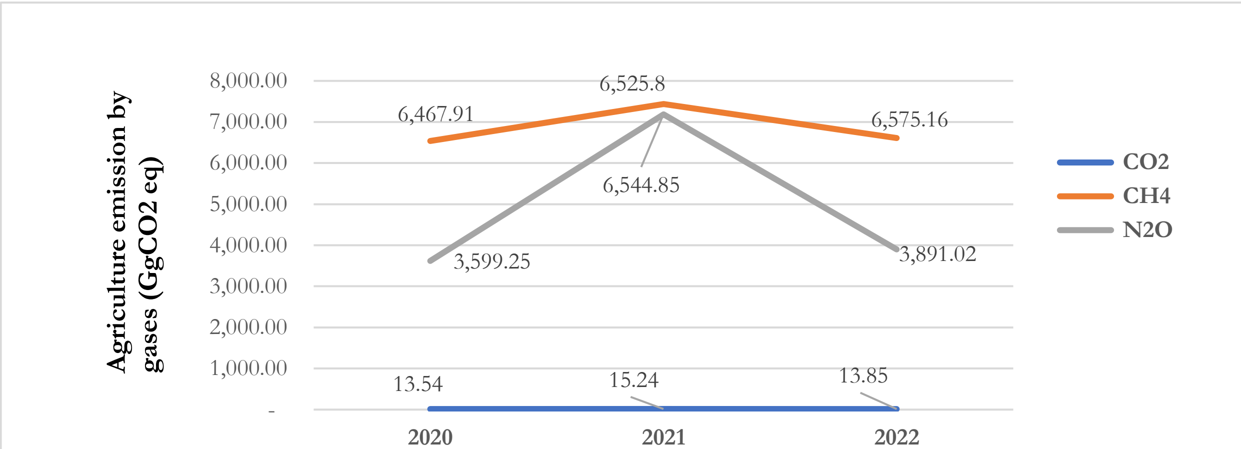


Figure 15 : Agriculture Emission by Gases, 2020 – 2022

5.1.1. Key Categories of Agriculture

Table 47: Key Categories of the Agriculture Sector (Including LULUCF)

No	A Code	B Category	C GHGs	AP1-L 2022	AP1-T 2020-2022
#7	3.A.1	Enteric Fermentation	CH_4	#7	#8
#8	3.D.1	Harvested Wood Products	CO_2	#8	#5
#9	3.C.4	Direct N_2O Emissions from managed soils	N_2O	#9	
#11	3.C.7	Rice cultivation	CH_4		
#12	3.A.2	Manure Management	CH_4		
#16	3.C.5	Indirect N_2O Emissions from managed soils	N_2O		
#17	3.A.2	Manure Management	N_2O		
#24	3.C.1	Burning	CH_4		
#27	3.C.1	Burning	N_2O		
#28	3.C.6	Indirect N_2O Emissions from manure management	N_2O		
#33	3.C.3	Urea application	CO_2		
#45	3.C.2	Liming	CO_2		

Note1: Ap1-L: Approach 1-Level Assessment, Ap1-T: Approach 1-Trend Assessment
Note2: Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

Table 48: Key Categories of Agriculture Sector (Excluding LULUCF)

No	A Code	B Category	C GHGs	AP1-L	AP1-T
#3	3.A.1	Enteric Fermentation	CH_4	#3	
#4	3.C.4	Direct N_2O Emissions from managed soils	N_2O	#4	#6
#6	3.C.7	Rice cultivation	CH_4	#6	#8

#7	3.A.2	Manure Management	CH_4	#7	
#10	3.C.5	Indirect N_2O Emissions from managed soils	N_2O	#10	
#11	3.A.2	Manure Management	N_2O	#11	
#17	3.C.1	Burning	CH_4		#4
#20	3.C.1	Burning	N_2O		#5
#21	3.C.6	Indirect N_2O Emissions from manure management	N_2O		
#25	3.C.3	Urea application	CO_2		
#36	3.C.2	Liming	CO_2		

Note1: Ap1-L: Approach 1-Level Assessment, Ap1-T: Approach 1-Trend Assessment
Note2: Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

5.2. Livestock Population Characterization

Livestock population characterization for the inventory of livestock section is prepared by using the approach in Section 10.2 Livestock Population and Feed Characterization. Based on national agricultural statistics and the FAO database, the significant animal populations in the country include cattle (non-dairy), buffalo, goats, swine, horses, and poultry (chickens, ducks, geese, and quails). For this inventory, emissions from enteric fermentation (and manure management) are estimated for these species, with the exception of quails due to the lack of specific parameters in the 2006 IPCC Guidelines.

Under the livestock section of the GHG inventory, emissions are estimated for six main species: cattle (non-dairy), buffalo, goats, swine, horse, and poultry. Currently, due to the lack of disaggregated data, a Tier 1 approach, as outlined in the 2006 IPCC Guidelines, Volume 4, Chapter 10, Section 10.3 (Methane Emissions from Enteric Fermentation) and Section 10.4 – 10.5 (Emissions from Manure Management), is primarily applied for basic characterization of emissions from enteric fermentation and manure management.

While dairy cows are considered a key category by the 2006 IPCC Guidelines in many contexts, there is a lack of evidence indicating the significance of this specific sub-category for Lao PDR's national emissions. Similarly, the sheep category is not native to Lao PDR, and there is a lack of information on its significance to the country; generally, sheep populations are grouped with goats in national agricultural statistics (e.g., Agricultural Statistics Yearbook). During the preparation of the GHG inventory, consultations with the Department of Livestock and Fisheries supported the consideration of dairy cow and sheep populations as currently small and insignificant contributors to the national context. As a result, emissions from dairy cows are assigned to the 'other cattle (non-dairy)' category, and emissions from sheep are included in the 'goat' category. This pragmatic grouping is employed given the current data limitations and the assessed insignificance of these sub-categories.

Recognizing the livestock sector as a key source of emissions for Lao PDR, there is a strong need for continuous improvement. Future efforts will prioritize enhancing the characterization of activity data for animal populations. Significant livestock species and subcategories must be identified to improve the accuracy of emission estimates. This will enable the use of country-specific emission factors and parameters, moving towards higher-tier methodologies. Further studies are planned to more definitively assess the significance of dairy cows and sheep populations for the country and to disaggregate their data if warranted.

5.3. Enteric Fermentation (3.A.1)

5.3.1. Category Description

Enteric fermentation is a digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption into the bloodstream. The amount of methane that is released depends on the type of digestive tract, age, and weight of the animal, the quality, and the quantity of the feed consumed. The main ruminant livestock are cattle, buffalo, goats, sheep, deer, and camelids. Non-ruminant livestock (horses, mules, asses) and monogastric livestock (swine) have relatively lower methane emissions because much less methane-producing fermentation takes place in their digestive systems.

In the CRT, the categories "dairy cows" and "sheep" are reported as "IE", since the numbers of animals in those categories are included in the figures for "other cattle" and "goats", respectively.

The total CH_4 emission released for 2022 was 3,678.03 GgCO_2 eq, while the CH_4 emission released for 2021 was 3,572.49 GgCO_2 eq and for 2020 was 3,464.58 GgCO_2 eq. In 2022, cattle were the highest emission source, accounting for 1,859.36 GgCO_2 eq, while the lowest emission source was horses, accounting for 16.38 GgCO_2 eq.

Table 49: Enteric Fermentation Emission by Livestock Category from 2020 – 2022

Activities data	GHG Gas	Emission result (Gg CO_2 eq)		
3.A.1 - Enteric Fermentation		**2020**	**2021**	**2022**
3.A.1.a – Cattle	CH_4	1,675.57	1,760.57	1,859.36
3.A.1.b – Buffalo	CH_4	1,556.91	1,563.22	1,572.05
3.A.1.d – Goats	CH_4	95.48	100.38	106.82
3.A.1.f - Horses	CH_4	16.28	16.33	16.38
3.A.1.h - Swine	CH_4	120.34	131.99	123.42
Total		**3,464.58**	**3,572.49**	**3,678.03**

5.3.2. Methodology Issues

a). Choice of Methods

Methane emissions from enteric fermentation were calculated by application of Tier 1, Equations 10.19 and 10.20, page 10.28, Chapter 10, Volume 4 of the 2006 IPCC Guidelines.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data (AD)

The activity data on Enteric fermentation covers: Other Cattle (non-dairy), Buffalo, Goats, Horses, Swine, and Poultry. Based on the 2006 IPCC Guidelines, the needed data for each species are livestock population, annual average population (head), number of days alive (DA), and typical animal mass (Kg). The detail of gained data is presented in (Table 50).

Table 50 : Livestock Population from 2020 - 2022

Animal Categories	Quantity (Head)			Source
	2020	2021	2022	
Other cattle [27]	2,188,000	2,299,000	2,428,000	Agricultural Statistics Yearbook 2020 and 2022
Buffalo [28]	1,234,000	1,239,000	1,246,000	
Goats [29]	682,000	717,000	763,000	
Horses [30]	32,303	32,405	32,507	FAOSTAT, Production, Livestock, Lao PDR
Swine [31]	4,298,000	4,714,000	4,408,000	Agricultural Statistics Yearbook 2020 and 2022
Poultry (Unspecified) [32]	45,023,903	46,014,510	47,929,152	
Chicken broiler [33]	243,682	315,168	335,764	
Chicken layer	1,612,430	1,730,509	1,804,870	
Duck broiler [34]	10,301	8,242	11,672	
Duck layer	152,200	135,310	150,405	
Goose	112,000	113,000	113,000	FAOSTAT, Production, Livestock, Lao PDR

d). Emission Factor

The EFs applied to Enteric fermentation for developing countries were used the default values. (2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.10). As other cattle and buffalo play a vital role in contributing to enteric fermentation emissions, their emission factors (EFs) were initially adjusted to align with national information on their weights. This initial approach used the methodology described on page 10.28, Chapter 10, Volume 4 of the 2006 IPCC Guidelines, which suggests 'one approach for developing the approximate emission factors is to use the Tier 1 emissions factor for an animal with a similar digestive system and to scale the emissions factor using the ratio of the weights of the animals raised to the 0.75 power' based on national weight data. (See Table 52 Adjusted EFs for Other Cattle and Buffalo below).

However, during the Quality Assurance (QA) process of the National Inventory Report (NIR), QA experts identified that this approach for developing approximate emission factors for other cattle and buffalo was not in line with the 2006 IPCC Guidelines Tier 1 approach. The Tier 1 method specifically requires the use of the default EFs provided in Tables 10.10 and 10.11 (Volume 4) for these species. The scaling approach cited is, in fact, intended for developing EFs for CH_4 emissions from enteric fermentation for other animals where default values are not explicitly provided in the 2006 IPCC Guidelines.

To resolve this issue and ensure alignment with the IPCC Guidelines, it is necessary to update the

[27] Use cattle weight from the guideline provided by the Department of Livestock and Fishery;
[28] Use buffalo weight from the guideline provided by the Department of Livestock and Fishery;
[29] Use goat weight from the guideline provided by the Department of Livestock and Fishery;
[30] No horse population is reported in the national yearbook. Hence, the number of horses taken from FAOSTAT https://www.fao.org/faostat/en/#data/QCL
[31] Swine population in the national statistic is not disaggregated by market and breeding swine. Hence, swine Weight from the guideline provided by the Department of Livestock and Fishery is disaggregated by farm and non-farm swine;
[32] The poultry that is reported in the national statistics is unspecified. Only small numbers are to be known as layer-broiler Chickens and ducks, as well as quails. Hence, since no default weight for unspecified poultry, the population is applied an average weight calculated by all poultry sub-categories that can be identified:
[33] Chicken broiler: A small number of chicken broilers are reported in the National Statistics Yearbooks. Hence, the number of days alive is estimated;
[34] Duck broiler: A small number of duck broilers are reported in the National Statistics Yearbook. Hence, the number of days alive is estimated while ducks and geese are used the default duck weight of 2.7 kg.

emission factors for enteric fermentation in buffalo and other cattle using the default values from Table 10.10 (buffalo, developing countries) and Table 10.11 (other cattle, Asia) of the 2006 IPCC Guidelines.

Table 51: Enteric Fermentation Emission Factor for Tier 1 Method

Livestock Category	Emission Factors (Head)	Source
Other cattle	27.35	Table …Adjusted EFs for Other Cattle and Buffalo below
Buffalo	45.06	
Goats	5	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.10 (p. 10.28) Goat (developing countries)
Horses	18	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.10 (p. 10.28) Horse (developing countries)
Swine	1	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.10 (p. 10.28) Swine (developing countries)
Broiler chickens	0	
Layer chickens	0	
Broiler ducks	0	Indicated as 'insufficient data for calculation' for poultry in 2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.10 (p. 10.28)
Layer ducks	0	
Geese	0	
Poultry (unspecified)	0	

Table 52: Adjusted EFs for Other Cattle and Buffalo

Livestock	Default Weight from 2006 IPCC Guidelines (Kg)	Default EF	National Average Weight (Kg)	Adjusted EF (Target Weight/Reference Weight^0.75) *EF	Source
Other Cattle	350	47	170	27.35	Default weight of other cattle is the average weight of mature males-grazing and mature females-grazing in Table 10A.2 (2006 IPCC Guidelines, Volume 4, Chapter 10)
Buffalo	300	55	230	45.06	Default weight of buffalo is in Table 10.10 2006 IPCC Guidelines, Volume 4, Chapter 10)

e). Livestock and Poultry Weight [35]

Table 53: Livestock and Poultry Weight

Livestock Category	Weight (Kg)	Source
Other cattle	170	Department of livestock and Fishery (2017), Guideline for strategic target of the livestock and Fishery
Buffalo	230	
Goats	25	

[35] Department of livestock and Fishery (2017): Guideline for strategic target of the livestock and Fishery

Horses	238	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10A-9, Horse (developing country) mass
Swine	65	Department of livestock and Fishery (2017), Guideline for strategic target of the livestock and Fishery, the average weight of farm and non-farm swine
Broiler chickens	1.2	Department of livestock and Fishery (2017), Guideline for strategic target of the livestock and Fishery
Layer chickens	1.5	
Broiler ducks	2.7	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10A-9, Poultry-ducks (developed country) mass
Layer ducks	2.7	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10A-9, Poultry-ducks (developed country) mass
Geese	2.7	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10A-9, Poultry-ducks (developed country) mass
Poultry (unspecified)	1.8	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10A-9, Poultry-layers (developed country) mass

5.4. Manure Management (3.A.2)

5.4.1. Category Description

The methane (CH_4) emission is released during the storage and treatment of manure and from manure deposited on pasture. The amount of manure produced and the portion of it that decomposes anaerobically are the main factors affecting methane (CH_4) emissions. When manure is stored or treated as a liquid (e.g., in lagoons, ponds, tanks, or pits), it decomposes anaerobically and can produce a significant quantity of methane (CH_4). When manure is handled as a solid (e.g., in stacks or piles) or when it is deposited on pastures and rangelands, it tends to decompose under more aerobic conditions, and less methane (CH_4) is produced.

Direct N_2O emission from manure management system (MMS) was released by mixing between nitrification and dentification of ammoniacal nitrogen contained in the manure. The amount of emission released depends on the systems and duration of manure management. Indirect N_2O emission occurred during the runoff and leaching, and the atmospheric deposition of N volatilized from the MMS.

In the CRT, the categories of "dairy cows" and "sheep" are reported as "IE", since the numbers of animals in those categories are included in the figures for "other cattle" and "goats", respectively.

After the QA process, the errors with the estimation of N_2O emissions from manure management for swine, goats, and poultry in the IPCC inventory Software have been fixed.
Their N2O emissions for these species are reported as 'NE'. This is because their emission estimates are considered as insignificant.

(Table 54) presents that the total methane emission for 2022 is 1,036.33 ($GgCO_2$ eq), in which the swine is the highest emission source, accounting for 863.97 ($GgCO_2$ eq), while the horses are the lowest emission source, accounting for 1.99 ($GgCO_2$ eq). The total N20 emission for 2022 is 498.68 ($GgCO_2$ eq), in which cattle are the highest emission source, accounting for 196.24 ($GgCO_2$ eq), while the lowest emission source is 114.30 ($GgCO_2$ eq).

Table 54: Manure Management Emission by Source from 2020 – 2022

Animal Categories	CH_4 Emission ($GgCO_2$ eq)			N_2O Emission ($GgCO_2$ eq)		
54321	**2020**	**2021**	**2022**	**2020**	**2021**	**2022**
3.A.1.a – Cattle	61.26	64.37	67.98	176.85	185.82	196.24
3.A.1.b – Buffalo	69.10	69.38	69.78	113.20	144.26	114.30

3.A.1.d – Goats	4.2	4.42	4.7	NE	NE	NE
3.A.1.f - Horses	1.98	1.99	1.99	NE	NE	NE
3.A.1.h - Swine	842.41	923.94	863.97	183.44	201.20	188.14
3.A.2.i - Poultry	25.95	26.75	27.91	NE	NE	NE
Total	1004.9	1090.85	1036.33	473.49	531.29	498.68

5.4.2. Methodology Issues

5.4.2.1. Methane Emission from Manure Management

a). Choice of Methods

The methane CH_4 emission is also produced during the storage and treatment of manure and from manure deposited on pasture. Manure is applied to both dung and urine (i.e., the solid and the liquids) produced by livestock. The emissions associated with dung burning for fuel are to be reported under the Energy and Waste if burned without energy recovery. The decomposition of manure under anaerobic conditions, in the absence of oxygens during storage and treatment, produced CH_4 emission. These conditions occur most readily when large animals are managed in a liquid-based system. The main factors affecting CH_4 emission are the manure amount produced and the portion of the manure that decomposes anaerobically. Initially, it depends on the rate of waste production per animal, the number of animals, and the latter on how the manure is managed. When manure is stored or treated as a liquid (e.g., in lagoons, ponds, tanks, or pits), it decomposes anaerobically and can produce a significant quantity of CH_4 emissions. Based on Figure 10.3, page10.36 on the decision tree for CH_4 emissions from manure management, the tier 1 approach, Equation 10.22, 2006 IPCC Guidelines, Chapter 10, Volume 4 was applied to estimate CH_4 emission in the manure management as there was no country specifies data.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data (AD)

The activity data for estimating CH_4 emission from manure management was the livestock population by animal category, such as other cattle, Buffalo, Goats, Horses, Swine, Poultry, Chicken broiler, Chicken layer, Duck broiler, Duck layer, and Goose. The detailed is present in (Table 55).

Table 55 : Livestock Population from 2020 – 2022

Animal Categories	Quantity (Head)			Source
	2020	2021	2022	
Other cattle [36]	2,188,000	2,299,000	2,428,000	Agricultural Statistics Yearbook 2020 and 2022
Buffalo [37]	1,234,000	1,239,000	1,246,000	
Goats [38]	682,000	717,000	763,000	
Horses [39]	32,303	32,405	32,507	FAOSTAT, Production, Livestock, Lao PDR

[36] Use cattle weight from the guideline provided by the Department of Livestock and Fishery;
[37] Use buffalo weight from the guideline provided by the Department of Livestock and Fishery;
[38] Use goat weight from the guideline provided by the Department of Livestock and Fishery;
[39] No horse population is reported in the national yearbook. Hence, the number of horses taken from FAOSTAT https://www.fao.org/faostat/en/#data/QCL

Swine [40]	4,298,000	4,714,000	4,408,000	Agricultural Statistics Yearbook 2020 and 2022
Poultry (Unspecified) [41]	45,023,903	46,014,510	47,929,152	
Chicken broiler [42]	243,682	315,168	335,764	
Chicken layer	1,612,430	1,730,509	1,804,870	
Duck broiler [43]	10,301	8,242	11,672	
Duck layer	152,200	135,310	150,405	
Goose	112,000	113,000	113,000	FAOSTAT, Production, Livestock, Lao PDR

d). Emission Factor

The EFs applied to estimate the CH_4 emission and N_2O from manure management was obtained default values from 2006 IPCC Guidelines

Table 56: Emission factor to estimate the CH_4 emission

Livestock Category	Emission Factors (Head)	Source
Other cattle	1	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.14 (p.10.39), Other Cattle (Asia), Warm (27)
Buffalo	2	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.14 (p.10.39), Buffalo (Asia), Warm (27)
Goats	0.22	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.15 (p.10.40), Goats (developing countries), Warm (>25˚C)
Horses	2.19	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.15 (p.10.40), Horse (developing countries), Warm (>25˚C)
Swine	7	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.14 (p.10.39), Swine (Asia), Warm (27)
Poultry (unspecified)	0.02	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.15 (p.10.40), Poultry (developing countries), Warm (>25˚C)
Chicken broiler	0.02	
Chicken layer	0.02	
Duck broiler	0.02	
Duck layer	0.02	
Goose	0.02	

5.4.2.2. N2O Emissions from Manure Management

a). Choice of Methods

Direct N_2O emissions occur via combined nitrification and denitrification of nitrogen in the manure. N_2O emissions from manure during storage and treatment depend on the manure's nitrogen and carbon content and the duration of storage and treatment. Nitrification, the oxidation of ammonia nitrogen to nitrate nitrogen) is a necessary prerequisite for N_2O emissions from stored animal

[40] Swine population in the national statistic is not disaggregated by market and breeding swine. Hence, swine Weight from the guideline provided by the Department of Livestock and Fishery is disaggregated by farm and non-farm swine;

[41] The poultry that is reported in the national statistics is unspecified. Only small numbers are to be known as layer-broiler Chickens and ducks, as well as quails. Hence, since no default weight for unspecified poultry, the population is applied an average weight calculated by all poultry sub-categories that can be identified:

[42] Chicken broiler: A small number of chicken broilers are reported in the National Statistics Yearbooks. Hence, the number of days alive is estimated;

[43] Duck broiler: A small number of duck broilers are reported in the National Statistics Yearbook. Hence, the number of days alive is estimated while ducks and geese are used the default duck weight of 2.7 kg.

manures. Nitrification is possible in stored animal manures, provided an inadequate oxygen supply exists. Nitrification does not occur under anaerobic conditions. In short, the production and emission of N_2O emissions from managed manures requires the presence of either nitrites or nitrates in an anaerobic environment preceded by aerobic conditions necessary for the formation of these oxidized forms of nitrogen. In addition, conditions preventing the reduction of N_2O emissions to N2, such as a low pH or limited moisture, must be present. N_2O emissions from manure management were estimated using default values from the IPCC Guideline 2006, as there were no country-specific values.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data (AD)

The activity data is the excretion rate of Nitrogen (N) treated by each livestock manure management system and the livestock population:

Livestock Population: Detailed of the number of livestock population are presented the section of CH_4 emission from livestock manure management (Table 57).

Annual N Excretion Rates: Annual N excretion for livestock category is estimated by using Equation 10.30 (2006 IPCC Guidelines, Volume 4, Chapter 10, p. 10.57).

Table 57: Average weight and nitrogen excretion rates in 2022

Livestock Category	Live Weight	N Excretion Rate (Kg N/1000 Kg mass/day	Nitrogen excreted (kg N/head/year)	Source (N Excretion Rate)
Other cattle	170	0.34	21.10	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.19 (p. 10.59), Other Cattle (Asia)
Buffalo	230	0.32	26.86	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.19 (p. 10.59), Buffalo (Asia)
Goats	25	1.37	12.50	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.19 (p. 10.59), Goats (Asia)
Horses	238	0.46	39.96	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.19 (p. 10.59), Horse (Asia)
Swine	65	0.4	9.49	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.19 (p. 10.59), Swine (Asia)
Poultry (unspecified)	1.8	0.82	0.54	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.19 (p. 10.59), Poultry (Asia)
Chicken broiler	1.2	0.82	0.36	
Chicken layer	1.5	0.82	0.45	

Duck broiler	2.7	0.82	0.81	
Duck layer	2.7	0.82	0.81	
Goose	2.7	0.82	0.81	

d). Emission Factor of Direct N_2O-N(kg) from Manure Management

Table 58: Emission Factor of Direct N_2O-N(kg) from Manure Management

Livestock Category	Emission Factor 3 - Direct N_2O-N (Kg)					Source
	EF-Daily Spread	Ef-Dry lot	Ef-Solid Storage	EF-Liquid/ Slurry	EF-Burned for fuel	
Other cattle	0	0.02	0	0	0	2006 IPCC Guidelines, Volume 4, Table 10.21 (p. 10.62 – 10.64), Dry lot
Buffalo	0	0.02	0	0	0	
Goats	0	0	0.005	0	0	2006 IPCC Guidelines, Volume 4, Table 10.21 (p. 10.62 – 10.64), Solid Storage
Horses	0	0	0	0	0	2006 IPCC Guidelines, Volume 4, Table 10.21 (p. 10.62 – 10.64)
Swine	0	0.02	0	0.005	0	2006 IPCC Guidelines, Volume 4, Table 10.21 (p. 10.62 – 10.64), Dry lot and Liquid/Slurry (with natural crust cover)
Poultry (unspecified)	0	0	0	0.005	0	2006 IPCC Guidelines, Volume 4, Table 10.21 (p. 10.62 – 10.64), Liquid/Slurry (with natural crust cover)
Chicken broiler	0	0	0	0.005	0	
Chicken layer	0	0	0	0.005	0	
Duck broiler	0	0	0	0.005	0	
Duck layer	0	0	0	0.005	0	
Goose	0	0	0	0.005	0	

e). Fraction of Manure Management System Usage

Table 59 : Fraction of manure management system usage

Livestock Category	Fraction of Manure Management System Usage							Source
	Pasture /Range	Daily Spread	Dry Lot	Solid Storag e	Liquid Slurry	Digester	Burne d for fuel	
Other cattle	0.50	0.02	0.4 6	0	0	0	0.02	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10A-5 (p.10.78), Asia
Buffalo	0.50	0.04	0.4 1	0	0	0	0.05	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10A-6 (p.10.79), Asia
Goats	0.50			0.50				2019 Refinement to the 2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10A.8, Goat (East Asia and South-East Asia)
Horses	0.50			0.50				
Swine			0.5 4		0.40		0.06	2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10A-7(8) (p.10.80-81), Asia (average of

								market swine and breeding swine)
Poultry (unspecified)	0.01	0.94			0.04	0.01		2019 Refinement to the 2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10A.9, Chicken Layer (East Asia and South-East Asia)
Chicken broiler	0.01	0.94			0.04	0.01		
Chicken layer	0.01	0.94			0.04	0.01		
Duck broiler	0.01	0.94			0.04	0.01		
Duck layer	0.01	0.94			0.04	0.01		
Goose	0.01	0.94			0.04	0.01		

5.5. Aggregated Sources and non- CO2 Emissions Sources on Land (3.C)

5.5.1. Burning (3.C.1)

a). Choice of Methods

The Tier 1 general approach from the 2006 IPCC Guidelines (Chapter 2, Volume 4) is employed to estimate emissions from burning activities. Default emission factors and assumptions of complete combustion are applied, utilizing Equation 2.27. Non- CO_2 emissions from burning are reported for forest lands, croplands, and grasslands, assuming burning occurs exclusively in land remaining in the same category due to data limitations. Wildfires are the primary focus in forest lands, while fire types in other land uses are generalized.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

Activity data are derived from national statistics, and FAO databases. Annual estimates include:

• Forest Lands: Burnt area data focused on wildfires. Prescribed fire data were not included.

• Croplands: Estimates of burning in croplands utilized crop production data from national agricultural reports and biomass burned data from FAOSTAT. Estimates were limited to crop types for which FAO residue biomass burning data was available. In the absence of specific data on areas involved in crop residue burning, the total harvested area of each crop type from Agricultural Statistics Yearbook 2022 was assumed to represent the burned area.

• Grasslands: For estimating burning in grasslands, biomass and area burned data were primarily sourced from FAOSTAT, which includes specific data for grassland and savanna land use types. A challenge arose, however, regarding savanna areas: the burned area reported by FAO was larger than the total savanna area derived from the National Forestry Monitoring System (NFMS), which serves as the basis for the inventory's land-use representation. To address this, the total savanna area reported by NFMS was assumed to be the total area involved in burning activities within savanna lands.

Table 60: Activity Data of Burning from 2020 – 2022

Land use affected by fire	Area Burned (ha)			Total Mass of Fuel Consumed (tonnes d.m.)			Source
	2020	2021	2022	2020	2021	2022	
Cropland (maize)	106,080	110,910	92,759	125,322.86	176,985.59	228,648.33	Agricultural Statistics Yearbook 2022 (Area); FAOSTAT, Residue Burning – Lao PDR (biomass burned)
Cropland (sugarcane)	24,002	23,013	30,435	15,170.82	18,813.13	22,455.44	
Cropland (rice)	916,640	939,662	957,629	506,935.00	518756.75	530578.49	
Grassland	73,140	33,680	20,498	380,260.08	175,135.98	106,566.23	FAOSTAT, Grassland Burning (Area and biomass burned)
Savanna	69,156	69,156	68,164	3,658,226.14	1,179,435.64	621,658.50	National Forestry Monitoring System (Area); FAOSTAT, Savanna Burning (biomass burned – sum of savanna and woody savanna)

d) Emission Factors and Parameters

Default emission factors from the IPCC guidelines (Tables 2.5, Chapter 2, Volume 4) are applied:

Savanna and Grassland:

- CO2: 1613 ± 95 g/kg
- CH_4: 2.3 ± 0.9 g/kg
- N_2O: 0.21 ± 0.10 g/kg

Agricultural Residues:

- CO_2: 1515 ± 177 g/kg
- CH_4: 2.7 g/kg
- N_2O: 0.07 g/kg

Tropical Forest:

- CO_2: 1580 ± 90 g/kg
- CH_4: 6.8 ± 2.0 g/kg
- N_2O: 0.20 g/kg

5.5.2. Liming (3.C.2)

a). Choice of Methods

The Tier 1 approach is used to estimate CO_2 emissions from liming, assuming complete dissolution of lime (e.g., limestone, dolomite) within the year of application. Emissions are calculated using Equation 11.12 of the 2006 IPCC Guidelines.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c) Activity Data

Annual lime application rates are estimated based on production, imports, and exports, assuming all available lime is applied to soils due to the absence of direct usage data.

Table 61: Activity Data for Liming from 2020-2022

Lime Type	Annual Amount of Lime (tonnes/year)			Source
	2020	2021	2022	
Limestone	2575	611	515	World Integrated Trade (28 Sep 2024), Lao PDR – Other Countries Trade Records
Dolomite	1110	1440	648	

d) Emission Factors and Parameters

Default emission factors from the 2006 IPCC Guidelines are as follows:

- Limestone (CaCO3): 0.12
- Dolomite (CaMg(CO3)2): 0.13

5.5.3. Urea Application (3.C.3)

a) Choice of Method

CO_2 emissions from urea application are estimated using the Tier 1 method, which models hydrolysis and subsequent conversion to ammonium and bicarbonate, releasing CO2. Calculations follow Equation 11.13 of the 2006 IPCC Guidelines.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c) Activity Data

The annual amount of urea applied is derived from domestic production, import/export data, and sales records, assuming all available urea is used in soils.

Table 62: Activity Data for Urea Application from 2020-2021

Carbonate N-fertilizer Type	Annual amount of Carbonate N-fertilizer available (tonnes/year)			Source
	2020	2021	2022	
Urea	16,202.00	19,482.00	18,153.93	FAOSTAT (17 Oct 2024), Lao PDR, Fertilizers by Product, Urea

d) Emission Factors and Parameters

The default emission factor for urea application, as per the 2006 IPCC Guidelines, is:

- **Urea:** 0.20

5.5.4. Direct N20 Emission from Managed Soil (3.C.4)

a) Choice of Method

The Tier 1 method estimated N_2O emissions from various nitrogen sources, including synthetic fertilizers, organic amendments, animal grazing, crop residues, and mineralized nitrogen. Emissions were calculated using Equation 11.1, and nitrogen inputs were categorized based on their sources and application methods.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c) Activity Data

Activity data were sourced from FAO agricultural databases and national statistics, focusing on annual nitrogen input rates for synthetic fertilizers and residues.

Synthetic fertilizer N applied data for Lao PDR on synthetic fertilizer N applied to the agriculture sector in 2020 and 2021 is sourced from FAOSTAT (09 Oct 2024). An extrapolation method is used for estimating the synthetic fertilizer N applied in 2022 due to the lack of data.

Managed manure N available for application to managed soils, feed, fuel or construction uses is estimated by using Equation 10.43 (2006 IPCC Guidelines, Volume 4, Chapter 10). Parameters used in the estimation include: number of head of livestock species, annual average N excretion per animal of each species, fraction of total annual nitrogen excretion for each livestock species managed in a manure management system, amount of managed manure nitrogen for livestock lost in the manure management system (2006 IPCC Guidelines, Volume 4, Chapter 10, Table 10.23), and amount of nitrogen from bedding. However, the data on the amount of nitrogen from bedding is not available.

N in urine and dung deposited by grazing animals on pasture, range and paddock is estimated by using Equation 11.5 (2006 IPCC Guidelines, Volume 4, Chapter 11). Parameters used in the estimation include: number of head of livestock species, annual average N excretion per animal of each species (see Table 56), and fraction of total annual nitrogen excretion for each livestock species (deposited on pasture, range, and paddock) in the manure management system.

N crop residues returned to soils is estimated by using Equation 11.6 (2006 IPCC Guidelines, Volume 4, Chapter 11). Equation 11.7 is used for estimating harvested dry matter yield for crops. Crop production data is sourced from Lao PDR – Agricultural Statistics Yearbook 2020 and 2022. Default factors for the estimation of N added to soils from different types of crop residues are from Table 11.2 (2006 IPCC Guidelines, Volume 4, Chapter 11).

Mineralized N resulting from loss of soil organic C stocks in mineral soils is estimated by using Equation 11.8 (2006 IPCC Guidelines, Volume 4, Chapter 11). Parameters used in the estimation include: average loss of soil carbon for each land-use type (from land use change and management data) and the C:N ratio of the soil organic matter (default values provided on p. 11.16 - 2006 IPCC Guidelines, Volume 4, Chapter 11).

Table 63 Activity Data of Direct N20 Emission from Managed Soil for 2020-2022

Activity Data	Unit	Annual Amount of N in Soils			Source
		2020	2021	2022	
Annual amount of synthetic fertilizer N applied	kg N/year	36,525,000	37,268,238	38,011,477	FAOSTAT (09 Oct 2024), Lao PDR, Fertilizers by Nutrient, Synthetic Fertilizer N for 2020 and 2021 data; Extrapolation for 2022
Amount of managed N available for application to soils	kg N/year	93,376,816.52	102,726,153.15	98,222,592.36	Estimated by using Equation 10.43 (2006 IPCC Guidelines, Volume 4, Chapter 10, p. 10.65)
Amount of N from N source deposited pasture, range and paddock	kg N/year	44,809,509.32	46,274,926.46	48,030,192.19	Estimated by using Equation 11.15 (2006 IPCC Guidelines, Volume 4, Chapter 11).
Amount of N crop residues returned to soils	kg N/year	319,027,642.96	900,237,323,95	389,862,569.43	Estimated by using Equation 11.6 (2006 IPCC Guidelines, Volume 4, Chapter 11)
Amount of mineralized N resulting from loss of soil organic C stocks in mineral soils	kg N/year	22,128,665.33	22,128,665.33	25,122,776.83	Estimated by using Equation 11.8 2006 IPCC Guidelines, Volume 4, Chapter 11)

d) Emission Factors and Parameters

Default emission factors as per the 2006 IPCC Guidelines (Table 11.1):

- Synthetic fertilizer applied: 0.01 kg N_2O -N/ kg N applied.
- Organic matter applied: 0.01 kg N_2O -N/ kg N applied
- N deposited by grazing livestock: 0.02 (for cattle) and 0.01 (for sheep and other animals) kg
  N_2O -
  N/ kg N deposited.
- N in crop residues: 0.01 kg N_2O -N/ kg N
- N mineralized: 0.01 kg N_2O -N/ kg N.

5.5.5. Indirect N20 Emission from Managed Soils (3.C.5)

a) Choice of Method

The Tier 1 method calculates indirect N_2O emissions resulting from nitrogen volatilization and leaching. Calculations use Equation 11.9 (N_2O from atmospheric deposition of n volatilized from managed soils) and Equation 11.10 (N_2O from n leaching/runoff from managed soils in regions where leaching/runoff occurs).

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c) Activity Data

Activity data include nitrogen inputs subject to volatilization and leaching, sourced from agricultural usage statistics including synthetic fertilizers, organic amendments, animal grazing, crop residues, and mineralized nitrogen.

Annual amount of synthetic fertilizer N that volatilizes is calculated by amount of N applied to soils and fraction of synthetic fertilizer N that volatilizes. Whereas the other N sources are as same as in the category of direct N_2O Emissions from Managed Soils.

Table 64: Activity Data of Indirect N20 Emission from Managed Soils

Activity Data	Unit	Annual Amount of N in Soils that Volatilizes			Source
		2020	2021	2022	
Annual amount of synthetic fertilizer N that volatilizes	kg NH3–N + NOx–N	3,652,500	3,726,823.8	3,801,147.7	See Table 62
Amount of animal manure, compost, sewage sludge, rendering waste and other organic amendments	kg N/year	93,376,816.52	102,726,153.15	98,222,592.36	
Amount of urine and dung N deposited by grazing animals	kg N/year	44,809,509.32	46,274,926.46	48,030,192.19	

Amount of N crop residues returned to soils	kg N/year	319,027,642.96	900,237,323,95	389,862,569.43	
Amount of mineralized N resulting from loss of soil organic C stocks in mineral soils	kg N/year	22,128,665.33	22,128,665.33	25,122,776.83	

d) Emission Factors and Parameters

Default emission factors as per the 2006 IPCC Guidelines (Table 11.3):

- Volatilization: 0.01 of nitrogen volatilized.
- Leaching: 0.0075 of nitrogen leached.

Default Values of N Fraction for Volatilization and Leaching:

- Fraction of synthetic fertilizer N that volatilizes: 0.1 kg NH3–N + NOx–N / kg N
- Fraction of organic N fertilizers applied, and dung and urine deposited by grazing animals that volatilize: 0.2 kg NH3–N + NOx–N / kg N
- Fraction of N losses by leaching/runoff: 0.3 kg N/ kg of N additions

5.5.6. Indirect N20 Emission from Manure Management (3.C.6)

a) Choice of Method

The Tier 1 method was used to estimate indirect N_2O emissions due to nitrogen losses through volatilization during manure management. Calculations follow Equation 10.26 (n losses due to volatilization from manure management) and Equation 10.27 (indirect N_2O emissions due to volatilization of n from manure management) of the IPCC guidelines.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c) Activity Data

Activity data include nitrogen content in managed manure systems, derived from livestock population and manure management practice statistics.

Table 65: Activity data of Indirect N20 Emission from manure management

Livestock Type	Manure Management System	Total N Excretion for the Manure Management System (kg N/year)			Source
		2020	2021	2022	
Other cattle	Dry lot	21,233,708.56	22,310,921.38	23,562,817.36	Estimated by multiplying the livestock population (see Table 50 or 54), N excretion rate for the animal species (see table 56), and
Swine	Liquid/slurry	16,315,208.00	17,894,344.00	16,732,768.00	

					fraction of manure in MMS (See Table 58)

d) Emission Factors and Parameters

The emission factor for N volatilization and re-deposition, as per the 2006 IPCC Guidelines (Table 11.13, Chapter 11), is: 0.01 kg N_2O –N (kg NH3–N + NOX–N volatilized).

- Default values of fraction of managed livestock manure N that volatilizes (%)
  Dry lot – Other cattle: 30%
  Liquid/slurry – Swine: 48%

5.5.7. Rice Cultivation (3.C.7)

a) Choice of Method

CH_4 emissions from rice cultivation are estimated using the Tier 1 method. The baseline emission factor (EF) is adjusted using scaling factors for water regime, organic amendments, and other variables as outlined in Equations 5.1 (CH_4 emissions from rice cultivation) and 5.2 (adjusted daily emission factor) of the IPCC guidelines.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c) Activity Data

Harvested area data were categorized by water regime (upland, irrigated, rainfed) and sourced from national agricultural reports.

Table 66: Activity Data for Rice Cultivation from 2020-2022

Rice ecosystem	Cultivation period (day)	Annual harvested area (ha/year)			Source
		2020	2021	2022	
Upland	160	105,214	81,373	92,605	Agricultural Statistics Yearbook 2022
Irrigated	140	96,193	86,960	95,480	
Rainfed	140	728,522	771,329	769,544	

d) **Emission Factors and Parameters**

The Baseline emission factor (EFc), as per the 2006 IPCC Guidelines (Table 5.11, Chapter 5), is 1.30 kg CH_4 ha-1 day-1 (default)

- Scaling factors:
  Water regime (SFw): Table 5.12.
  Upland: 0 (aggregated case)
  Irrigated: 0.78 (aggregated case)
  Rainfed: 0.27 (aggregated case)
- Conversion factor for Organic amendments (SFo): Table 5.14. Straw incorporated shortly (<30 days) before cultivation: 1
- Pre-cultivation water status (SFp): Table 5.13. Water regime prior to rice cultivation: 1.22 (Aggregated case)

CHAPTER VI: LAND USE, LAND-USE ANGE AN FORESTRY (LULUCF)

6.1. Overview of the Sector

The land use, land use change, and forestry (LULUCF) sector address with greenhouse gas (GHG) emissions and removal resulting from the forestry activities and land use change. The GHG emissions and removal occurs in this sector compromise carbon stock changes in five carbon pools, such as living aboveground biomass, living below ground biomass, dead organic matter in wood, dead organic matter in litter, and soil organic matter. The LULUCF Sector consists of the following categories:

- Forest land (3.B.1);
- Cropland (3.B.2);
- Grassland (3.B.3.);
- Wetland (3.B.4);
- Settlement (3.B.5);
- Other land (3.B.6)
- Harvested wood products (3.D)

LULUCF comprise both sources and sinks. The net removals for 2022 were -21,453.47 Gg CO_2 eq. The change of net removal was decreased 67.81% compared to the year 2020.

Table 67: Total Net Removals and Sinks for LULUCF, 2020 - 2022 (Gg- CO2 eq)

Category	2020	2021	2022
4. Land use, land-use change and forestry	**(102,530.64)**	**(104,469.40)**	**(60,297.51)**
4.A. Forest land	(102,426.54)	(101,103.47)	(99,566.97)
4.B. Cropland	(1,003.30)	(1,003.30)	37,458.47
4.C. Grassland	(0.22)	(0.22)	20.24
4.D. Wetlands	0.00	0.00	1.30
4.E. Settlements	0.00	0.00	317.67
4.F. Other land	1,040.70	1,040.70	4,157.45
4.G. Harvested wood products	(141.27)	(3,403.10)	(2,685.68
4.H. Other	NO	NO	NO

Table 68: Methodological Tiers used in the LULUCF [44]

Greenhouse Gas Categories	CO_2		CH_4		N_2O	
	Method applied	**EF**	**Method applied**	**EF**	**Method applied**	**EF**
3.B.1. Forest Land	T1	D	T1	D	T1	D
3.B.2. Cropland	T1	D	T1	D	T1	D
3.B.3. Grassland	T1	D	T1	D	T1	D
3.B.4. Wetlands	T1	D	T1	D	T1	D
3.B.5. Settlements	T1	D	T1	D	T1	D
3.B.6. Other land	T1	D	T1	D	T1	D
3.D.1. Harvested Wood Products	T1	D	T1	D	T1	D

[44] As lack of data in the country, Tier 1 approach is applied to estimate CO_2 emissions even for key categories in the LULUCF sector. Lao PDR intends to make efforts to use higher tiers for key categories in the future BTRs.

6.1.1. Key Categories in LULUCF

Table 69: Key Categories of LULUCF   Sector (Including LULUCF)

No	A Code	B Category	C GHGs	AP1-L 2022	AP1-T 2020-2022
#1	3.B.1.a	Forest land Remaining Forest land	CO_2	#1	#2
#2	3.B.2.b	Land Converted to Cropland	CO_2	#2	#1
#4	3.B.1.b	Land Converted to Forest land	CO_2	#4	#6
#6	3.B.6.b	Land Converted to Other land	CO_2	#6	#4
#8	3.D.1	Harvested Wood Products	CO_2	#8	#5
#15	3.B.2.a	Cropland Remaining Cropland	CO_2		#9
#21	3.B.5.b	Land Converted to Settlements	CO_2		
#32	3.B.3.b	Land Converted to Grassland	CO_2		
#43	3.B.4.b.ii	Land converted to Flooded Land	CO_2		

Note1: Ap1-L: Approach 1-Level Assessment, Ap1-T: Approach 1-Trend Assessment
Note2: Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

6.2. Land-Use Definitions and the Land Representative Approach

Table 70: Lao's national land-use classification

No	Land Use Type	Definitions
01	Evergreen Forest (EG)	Defined as a multi storey forest consisting of more than 50% trees of evergreen species. Most of the trees have long and cylindrical boles, many of them with a big buttress. Usually, the height of the trees of the upper storey is more than 30 m. The dense second storey prevents most of the light from reaching the ground floor. Another typical characteristic of this forest type are climbers and lichen on the tree stems. Bamboo is usually not found except when the canopy has been opened.
02	Mixed Deciduous Forest (MD)	Defined as the deciduous tree species represent more than 50% of the stand. The forest storeys are not as dense as those of evergreen types and most of the seedlings and saplings are deciduous trees. Most often bamboo occurs in this type of forest.
03	Dry Dipterocarp Forest (DD)	Defined as the Dry Dipterocarp Forest occurs in open stands. The tree diameter is comparably small and the height of the stand varies from 8 to 25 m. The crowns do not spread out widely. This type of forest is normally found in places with shallow soil, where the hard pan emerges above the ground, and on laterized soil. The forest consists of Many species being characteristically as fire resistant and have a thick bark such as: Mai Sabeng (Dipterocarpus intricatus), Mai Chick (Shorea obtusa), Mai Sat (Dipterocarpus obtusifolius), Mai Suak (Terminalia tomen-tosa) , Mai Hang (Shorea siamensis), Mai Khoung (Dipterocarpus tuberculatus ROXB).
04	Coniferous Forest (CF)	Defined as the Coniferous Forest is usually with single storied and open but the young growth may sometimes form a dense second storey. This forest type occurs in higher elevations and cold weather. The forest consist of pines (Pinus kesiya or Pinus merkusii), Mai hinghom(Keteleeria davidiana BEISSN) and Mai Longleng (Cunninghmia sinensis).
05	Mixed Coniferous and Broadleaved Forest (MCB)	Defined as the coniferous trees could be mixed with either deciduous or evergreen trees. In general, the Mixed Coniferous Forest is a transition type between the coniferous and the broadleaved forest types. It is also found in higher elevations.
06	Forest Plantation (P)	Defined as all planted tree which is the same or various species mixed together, with the same age, height and spacing. All plantations

		(including young ones with a crown density less than 20 %, and DBH less than 10 cm.) should be classified as Forest Plantations.
07	Bamboo (B)	Defined as the area covered with bamboo more than 80%. Abandoned upland crop is often recovered by bamboo. Bamboo brakes may vary in height from 2 m to 25 m depending on their species.
08	Regenerating Vegetation (RV)	Defined as the previously forested areas in which the crown density has been reduced to less than 20% because of logging or heavy disturbance includes shifting cultivation. If the area is left to grow undisturbed it will become forest again.
09	Savannah (SA)	Defined as an area where the soil conditions are unsuitable for tree growth as well as agriculture production. The tree cover in the Savannah should be at least 1% but less than 20%. The trees are drought resistant and mostly short with graminaceous and herbaceous plants forming an under storey. Mostly found in plain areas.
10	Scrub (SR)	Defined as an area covered with scrub and stunted trees. The soil is shallow and rocky. Inaccessible parts of lime stone formations covered with scrub and stunted trees should be classified as Scrub.
11	Grassland (G)	Defined as an area covered with scrub and stunted trees. The soil is shallow and rocky. Inaccessible parts of lime stone formations covered with scrub and stunted trees should be classified as Scrub.
12	Swamp - Wetland (SW)	Defined as areas where the soil is saturated with water all around the year. The soil may basically be fertile but the least lack of oxygen limits its agriculture or forest-production capacity. The wetland could have a high ecological or environmental value and rich of biodiversity's.
13	Upland Crop (UC)	Defined as an area where the forest has been cut and burnt for temporary cultivation of rice and other crops. Area that has been abandoned for more than 2 years should be classified as Regenerating Vegetation.
14	Rice Paddy (RP)	Defined as an area permanently being used for rice cultivation. Old paddy that has been abandoned for more than one year should not be classified as Rice Paddy.
15	Other Agriculture (OA)	Defined as the agricultural land being used for production of other crops than rice and agriculture plantation, i.e. various kinds of vegetables such as sugarcane, millet, cotton, and etc.
16	Agriculture Plantation (AP)	Defined as areas of agricultural land being used for fruit tree cultivation example: mango tree, longans tree, etc. Plantations with cash crops, which is the perennial crop for example: tea, cacao, and coffee also refer to this land use class.
17	Urban Area (U)	Defined as all areas being used for permanent settlements such as villages, towns, public gardens, industrial zone, and human settlements of any size.
18	Barren Land and Rock (BR)	Defined as the area which neither trees nor grasses can grow, shallow soil and rocky areas.
19	Other Land	Defined as the road, temple, cemeteries and some historical and cultural sites.
20	Water - River (W)	Defined as the river and small waterways should be at least 10m wide. In other cases, it should be joined to adjacent land use class.

6.3. Land (3B)

6.3.1. Land and Forest Classification

The land and forest classification in Lao PDR is divided into two level, namely, Level 1 comprising of seven classifies (Current Forest, Potential Forest, Other vegetated Areas, Cropland, Settlement, Other land, and Above-ground Water Source), and Level 2 included in the sub categories of Level 1. The detailed is presented in (Table 71).

Table 71: The land and forest classification[45]

IPCC Land-Use Category	National Level Classification System		
	Level 1	Level 2	
Forest Land	Current Forest	Evergreen Forest	EG
		Mixed Deciduous Forest	MD
		Dry Dipterocarp Forest	DD
		Coniferous Forest	CF
		Forest Plantation	P
	Potential Forest	Bamboo	B
		Regenerating vegetation	RV
Grassland	Other Vegetated Areas	Savannah	SA
		Scrub	SR
		Grassland	G
Cropland	Cropland	Upland crop	UC
		Rice paddy	RP
		Other Agriculture	OA
		Agriculture plantation	AP
Settlements	Settlement	Urban areas	U
Other land	Other land	Barren Land and Rock	BR
		Other Land	O
Wetlands	Above-ground water source	River (Water)	W
		Wetland (Swamp)	SW

Data of total land-use area, including changes between categories, are built using an approach designed to assess net changes in land-use categories and the conversions between them over time. This method enables the tracking of land-use transitions, capturing shifts both into and out of specific categories. By estimating the initial and final areas for all types of land-use conversions, as well as the total unchanged land within each category, the approach provides a comprehensive understanding of land-use dynamics. This structured assessment is particularly useful for identifying patterns of land-use change and their implications.

(Table 72) applies this approach to summarize the total area and transitions in land use between 2005 and 2022 for various categories. The matrix presents the areas of land that remained unchanged within each category and the areas that shifted from one category to another. The row and column totals indicate net conversions during this period. "Initial" represents the category at the start of the assessment, while "Final" denotes the category at its end. Net changes (in the final column) are derived by subtracting the initial area from the final area for each category. Blank entries indicate that no conversions were recorded for those transitions. The total land area of Lao PDR reported in the land use tracking system of the inventory is 23,054,258 hectares. This number is consistent with the total land area of the country in the National Forestry Monitoring System (NFMS) of the Department of Forestry, Ministry of Agriculture and Forestry. The NFMS is the main source for collecting data on land use changes and carbon stock parameters for the inventory. National experts from the Department of Forestry confirmed that the 23,054,258 hectares figure is derived from their analysis using geographic information systems. This total land area of 23,054,258 hectares was also reported in the department's documents submitted to the UNFCCC, such as the Lao PDR FREL (2018).

However, during the QA process, the QA experts suggested the need for justification for the selection of the land area value used in the inventory and carefully ensuring its consistency with other national reports and sources, as well as taking into account the official national land area.

[45] MAF (2018). Lao People's Democratic Republic Forest Reference Emission Level and Forest Reference Level for REDD+ Results Payment under the UNFCCC

Table 72: Land use Matrix from 2005 – 2022

Initial		Forest Land		Cropland		Grassland		Wetlands		Settlements		Other Land		2022	
Final		Managed Forest Land	Unmanaged Forest Land	Cropland Annual Crops	Cropland Perennial Crops	Managed Grassland	Unmanaged Grassland	Managed Wetlands	Unmanaged Wetlands	Settlements (Treed)	Settlements (Other)	Managed Other Land	Unmanaged Other Land	Final Area (ha)	Net Change (ha)
Forest Land	Managed Forest Land	19216989		157976	10225	1431		10			59		843	19387533	(-32165)
	Unmanaged Forest Land													0	0
Cropland	Cropland Annual Crops	190403		2346699	1655	1003		6			51		383	2540200	28826
	Cropland Perennial Crops	1460		1768	71178	9		2					1	74418	(-8655)
Grassland	Managed Grassland	70		255	6	344440								344771	(-2142)
	Unmanaged Grassland													0	0
Wetlands	Managed Wetlands	2		71				326						399	55
	Unmanaged Wetlands								5728					5728	0
Settlements	Settlements (Treed)													0	0
	Settlements (Other)	968		2126	2	21					100863		23	104003	3010
Other Land	Managed Other Land	9856		2429	7	9					20	122112	55	134488	12376
	Unmanaged Other Land												462718	462718	(-1305)
2005	Initial Area	19419748	0	2511324	83073	346913	0	344	5728	0	100993	122112	464023	23054258	0

Table 73: Land Use and Land Use Change from 2005 – 2022

	Land-Use Change (ha) in the Year of Conversion [46]					Conversion period [47]
	2005	2010	2015	2019	2022	Number of years
3.B.1.b.i Crop land Converted to Forest land	209,234	272,345		152,987	168,203	20
3.B.1.b.ii Grassland Converted to Forest land	142	4,452	237	339	1,431	20
3.B.1.b.iii Wetland Converted To Forest land	63	89	334	6	10	20
3.B.1.b.iv Settlement Converted to Forest land	90	65	198	254	60	20
3.B.1.b.v Other land Converted to Forest land	221	131	302	2,017	843	20
3.B.2.b.i Forest land Converted to Crop land	451,690	662,403	300,327	232,260	191,865	20
3.B.2.b.ii Grassland Converted to Crop land	4,502	7,268	2,578	35,537	1,012	20
3.B.2.b.iii Wetland Converted to Crop land	511	450	52	3,332	8	20
3.B.2.b.iv Settlement Converted to Crop land	5	-	558	142	51	20
3.B.2.b.v Other land Converted to Crop land	42	20	807	8,290	383	20
3.B.3.b.i Forest land Converted to Grassland	731	210	260	175	70	20
3.B.3.b.ii Crop land Converted To Grassland	754	764	53	285	262	20
3.B.3.b.iii Wetland Converted to Grassland	-	-	-	-	-	20
3.B.3.b.iv Settlement Converted to Grassland	-	-	-	-	0	20
3.B.3.b.v other land Converted to Grassland	24	-	6	-	0	20
3.B.4.a.i Peat extraction remaining peat extraction	No data	No data	No data	No data	No data	20
3.B.4.a.ii Flooded land remaining flooded land	No data	No data	No data	No data	No data	20
3.B.4.b.i Land converted peat extraction	No data	No data	No data	No data	No data	20
3.B.4.b.ii Land Converted to flooded land	193	133	0	0	73	20
3.B.5.b.i Forest land Converted to Settlement	244	2,302	1,927	9,238	968	20
3.B.5.b.ii Crop land Converted to Settlement	464	6,444	1,148	14,947	2,128	20
3.B.5.b.iii Grassland Converted to Settlement	60	308	68	420	21	20
3.B.5.b.iv Wetland Converted to Settlement	-	5	-	9	0	20
3.B.5.b.v other land Converted	430	-	47	1,228	23	20

[46] As there is no annual reports on area change, this inventory is applied gap (4-5 years) area data for tracking. Tracking determines the last year of each period data as a year of conversion (e.g., from the data of 2019-2022, the conversion year is 2022;

[47] Conversion year is a default value from the Chapter 4, Vol.4, 2006 IPCC Guidelines

to Settlement						
3.B.6.b.i Forest land Converted to Other land	3,076	54,433	17,866	26,073	9,855	20
3.B.6.b.ii Crop land Converted to Other land	543	4,919	2,735	3,241	2,437	20
3.B.6.b.iii Grassland Converted to other land	34	6,062	183	376	9	20
3.B.6.b.iv Wetland Converted To Other land	2	57	10	142	0	20
3.B.6.b.v Settlement Converted to other land	-	53	92	89	20	20

6.3.2. Methodology Issues

a). Emission/Removal Source and GHG Inventory Method

Land use change and forestry activities are the substantial sources that generate GHG emission/removal for Land (3B). The primary activities include the change in soil carbon stocks (mineral soil, organic soil, and inorganic substance in soil), the change in dead organic matter carbon stocks (dead wood and litter), and the change in living biomass carbon stock (above and below ground biomass). The method for changing those activities includes the following:

- The method for changing carbon stocks in dead wood and litter is applied equation 2.23, Page 2.26, Chapter 2, Volume 4 (2006 IPCC Guideline);
- The method for changing carbon stock in the soil is applied in Equation 2.24, page 2.29, page 2.25, page 2.30, and Equation 2.26, page 2.35 (2006 IPCC Guidelines, Chapter 2, volume 4);
- The method for changing living biomass carbon stock (above and below ground biomass) is the applied gain and loss method. This includes the Land remaining the same Land applied;
- Equation 2.7, 2.8, 2.9 (2006 IPCC Guidelines Page 2.15, Chapter 2, Volume 4) and Land
  converted to other Land applied equations 2.15 and 2.16 (2006 IPCC Guidelines Page 2.20, Chapter 2, Volume 4);
- For practical reasons in using the IPCC Inventory Software, it was assumed that the soil type is "Low Activity Clay Mineral" defined in Table 2.3, Chapter 2, Volume 4 of the 2006 IPCC Guidelines, in all land areas in the country. According to the survey conducted in 2009, the frequency distribution of soil types in Laos is as follows [48]**:**
  - Acrisols: The most common soil group, covering 73% of the country's surface area
  - Cambisols: 12% of the country's surface area
  - Luvisols: 4% of the country's surface area
  - Arenosols, Ferralsols, and Gleysols: About 2% of the country's surface area

However, the information on geo-spatial distribution of the land areas with each of these soil types is not available, therefore it is not possible to specify the exact soil type of each land unit used in the GHG inventory. Under this situation, Lao PDR has decided to assume all land areas are with the soil type "Low Activity Clay Mineral" which includes Acrisols and Ferralsols that

[48] Chaplot, Vincent & Bouahom, Bounthong & Valentin, Christian. (2009). Soil organic carbon stocks in Laos: Spatial variations and controlling factors. Global Change Biology. 16. 1380 - 1393. 10.1111/j.1365-2486.2009.02013.x. https://www.researchgate.net/publication/229921967_Soil_organic_carbon_stocks_in_Laos_Spatial_variations_and_controlling_factors#pf3

account for more than 70% of the country's entire territory area. This assumption will be reconsidered to improve the accuracy of GHG inventory in the future BTR submissions.

6.3.3. Forest Land (3B1)

This chapter provides methods for estimating greenhouse gas emissions and removals due to changes in biomass (above-ground and below-ground biomass), dead organic matter (dead wood, litter), and soil organic matter. It also will address carbon stock changes in managed forests owing to anthropogenic activities, such as establishing and harvesting plantations, commercial felling, fuelwood gathering and other management practices, and natural losses caused by fire, windstorms, insects, disease, and other disturbances (IPCC Guideline 2006, Chapter 4, page 4.7). The forest land covers the remaining forest land and land converted to forest land, and the greenhouse gases (GHG) removal from forest land for 2022 is shown in (Table 73).

Lao PDR operates under a national forest definition, established by the Land Law (2003) and Forestry Law (2007). This definition considers as forest any land officially designated as forest land by the government, as well as other areas, encompassing both currently forested and temporarily cleared sites. This very definition, which you can see summarized in the (Table 74), is vital for constructing the proposed Forest Reference Emission Level/Forest Reference Level (FREL/FRL).

Table 74: Forest definition of Lao PDR

Parameter	Value
DBH	Minimum of 10 cm
Crown density	Minimum of 20%
Area	Minimum of 0.5 ha

The choice of this forest definition over a more conventional one (which typically includes a height threshold) is primarily aimed at achieving better results in identifying land cover classes through remote sensing. Specifically, applying this definition with a minimum average stand DBH of 10cm allows for the exclusion of land covered with small-diameter trees that a height-based definition might have classified as forest. Additionally, to prevent the misinterpretation of trees in rice paddy landscapes as forests—especially in flatland areas where their canopy cover can often exceed 10% when viewed through remote sensing—a 20% crown density threshold has been adopted. This consistent forest definition has not only been used in the past two National Communications on Climate Change submitted to the UNFCCC but will also be employed nationally for future GHG inventory compilations, starting with the Third National Communication, which the Government intends to submit in early 2019[49].

6.3.3. 1. Forest Land Remaining Forest Land (3B1.a)

a). Methodology

Gain-loss method was used for estimating greenhouse gas emissions and removals from forest land remaining forest land (2006 IPCC Guidelines, Chapter 2, Volume 4, Equation 2.7, page 2.12). This method requires the above-ground biomass growth, biomass conversion and expansion factor (BCEF), and basic wood densities according to each forest type and climatic

[49] DOF, 2018: Lao PDR's Forest Reference Emission Level and Forest Reference Level for REDD+ Results Payment under the UNFCCC, Department of Forestry, Ministry of Agriculture and Forestry, Lao PDR

zone in the country, plus emission factors related to biomass loss, including losses due to wood removals, fuelwood removals and disturbance.

Carbon Stock Change in Biomass

- The annual change of carbon stocks in biomass can be estimated using the gain-loss method;
- Based on Tables 4.9, 4.10, and 4.12 to estimate the values of the above-ground biomass growth;
- Below-ground carbon stock changes can be zero as a default assumption consistent with the 2006 IPCC Guidelines

Carbon Stock Change in Dead Organic Matter (DOM)

- Tier 1 methods assume that the net carbon stock change in DOM pools is zero because the simple input and output equations used in Tier 1 methods are not suitable to capture the DOM pools;
- Tier 1 method assumes that the dead wood and litter carbon stocks are in equilibrium so that the change stock in the DOM pools are assumed to be zero;
- Tier 1 method require no activity data for estimation of change in carbon stock in DOM in Forest Land Remaining Forest Land;

Carbon Stock Change in Soil Carbon

- Tier 1 method assumes that forest soil carbon stocks do not change with management;
- The forest soil C stocks do not change with management in mineral soils

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data (AD)

The activity data for estimating greenhouse gas emissions and removal from forest land remaining fore land included as follows:

- Area of managed forest land according to different forest types, climate, management systems, and regions;
- Annual wood removals (m^3/y),
- Annual volume of fuelwood removal of whole trees (m^3/y);
- Annual volume of fuelwood removal as tree parts (m^3/y);
- Area affected by disturbances (ha/y);
- Area of land type included Evergreen, Mixed Deciduous, Coniferous Forest, and Mixed Coniferous and Broadleaved.

Table 75: Forest Land Remaining Forest Land Areas between 2005-2022

Initial Land Use	Land Type in Reporting Year	Area (ha)	Year of Conversion
Evergreen (EG)	Evergreen (EG)	2,558,628	NA
Regenerating Vegetation (RV)	Evergreen (EG)	484	2022
Mixed Deciduous (MD)	Evergreen (EG)	195	2022
Dry Dipterocarp (DD)	Evergreen (EG)	20	2022

Upland Crop (UC)	Evergreen (EG)	5	2022
Mixed Deciduous (MD)	Evergreen (EG)	388	2019
Regenerating Vegetation (RV)	Evergreen (EG)	143	2019
Bamboo (B)	Evergreen (EG)	17	2019
Mixed Deciduous (MD)	Evergreen (EG)	773	2010
Regenerating Vegetation (RV)	Evergreen (EG)	46	2010
Mixed Deciduous (MD)	Evergreen (EG)	3,039	2005
Regenerating Vegetation (RV)	Evergreen (EG)	14	2005
Mixed Deciduous (MD)	Mixed Deciduous (MD)	8,384,656	NA
Regenerating Vegetation (RV)	Mixed Deciduous (MD)	176,144	2022
Evergreen (EG)	Mixed Deciduous (MD)	718	2022
Plantation Forest (P)	Mixed Deciduous (MD)	50	2022
Dry Dipterocarp (DD)	Mixed Deciduous (MD)	41	2022
Coniferous Forest (CF)	Mixed Deciduous (MD)	32	2022
Mixed Coniferous and Broadleaved (MCB)	Mixed Deciduous (MD)	23	2022
Bamboo (B)	Mixed Deciduous (MD)	8	2022
Regenerating Vegetation (RV)	Mixed Deciduous (MD)	91,682	2019
Dry Dipterocarp (DD)	Mixed Deciduous (MD)	1,149	2019
Evergreen (EG)	Mixed Deciduous (MD)	891	2019
Plantation Forest (P)	Mixed Deciduous (MD)	140	2019
Bamboo (B)	Mixed Deciduous (MD)	88	2019
Regenerating Vegetation (RV)	Mixed Deciduous (MD)	107,254	2015
Evergreen (EG)	Mixed Deciduous (MD)	355	2015
Bamboo (B)	Mixed Deciduous (MD)	23	2015
Dry Dipterocarp (DD)	Mixed Deciduous (MD)	10	2015
Regenerating Vegetation (RV)	Mixed Deciduous (MD)	83,993	2010
Evergreen (EG)	Mixed Deciduous (MD)	1,827	2010
Dry Dipterocarp (DD)	Mixed Deciduous (MD)	32	2010
Dry Dipterocarp (DD)	Mixed Deciduous (MD)	22,721	2005
Regenerating Vegetation (RV)	Mixed Deciduous (MD)	20,567	2005
Evergreen (EG)	Mixed Deciduous (MD)	233	2005
Bamboo (B)	Mixed Deciduous (MD)	27	2005
Plantation Forest (P)	Mixed Deciduous (MD)	21	2005
Coniferous Forest (CF)	Coniferous Forest (CF)	122,930	NA
Mixed Coniferous and Broadleaved (MCB)	Coniferous Forest (CF)	13	2022
Mixed Deciduous (MD)	Coniferous Forest (CF)	10	2022
Regenerating Vegetation (RV)	Coniferous Forest (CF)	1	2022
Regenerating Vegetation (RV)	Coniferous Forest (CF)	76	2010
Mixed Coniferous and Broadleaved (MCB)	Mixed Coniferous and Broadleaved (MCB)	105,914	NA
Evergreen (EG)	Mixed Coniferous and Broadleaved (MCB)	5	2022
Regenerating Vegetation (RV)	Mixed Coniferous and Broadleaved (MCB)	1	2022
Regenerating Vegetation (RV)	Mixed Coniferous and Broadleaved (MCB)	3	2015
Regenerating Vegetation (RV)	Mixed Coniferous and Broadleaved (MCB)	113	2010
Regenerating Vegetation (RV)	Mixed Coniferous and Broadleaved (MCB)	147	2005
Dry Dipterocarp (DD)	Dry Dipterocarp (DD)	1,151,715	NA
Regenerating Vegetation (RV)	Dry Dipterocarp (DD)	89	2022
Plantation Forest (P)	Dry Dipterocarp (DD)	57	2022
Mixed Deciduous (MD)	Dry Dipterocarp (DD)	29	2022
Mixed Deciduous (MD)	Dry Dipterocarp (DD)	2,125	2019

Regenerating Vegetation (RV)	Dry Dipterocarp (DD)	268	2019
Plantation Forest (P)	Dry Dipterocarp (DD)	40	2019
Evergreen (EG)	Dry Dipterocarp (DD)	4	2019
Mixed Deciduous (MD)	Dry Dipterocarp (DD)	313	2015
Regenerating Vegetation (RV)	Dry Dipterocarp (DD)	91	2015
Evergreen (EG)	Dry Dipterocarp (DD)	13	2015
Regenerating Vegetation (RV)	Dry Dipterocarp (DD)	862	2010
Regenerating Vegetation (RV)	Dry Dipterocarp (DD)	778	2005
Mixed Deciduous (MD)	Dry Dipterocarp (DD)	5	2005
Plantation Forest (P)	Plantation Forest (P)	84,755	NA
Regenerating Vegetation (RV)	Plantation Forest (P)	44,004	2022
Mixed Deciduous (MD)	Plantation Forest (P)	9,091	2022
Dry Dipterocarp (DD)	Plantation Forest (P)	4,591	2022
Evergreen (EG)	Plantation Forest (P)	657	2022
Bamboo (B)	Plantation Forest (P)	392	2022
Mixed Deciduous (MD)	Plantation Forest (P)	11,824	2019
Dry Dipterocarp (DD)	Plantation Forest (P)	2,246	2019
Evergreen (EG)	Plantation Forest (P)	158	2019
Dry Dipterocarp (DD)	Plantation Forest (P)	15,238	2015
Mixed Deciduous (MD)	Plantation Forest (P)	7,390	2015
Evergreen (EG)	Plantation Forest (P)	48	2015
Dry Dipterocarp (DD)	Plantation Forest (P)	18,413	2010
Mixed Deciduous (MD)	Plantation Forest (P)	14,557	2010
Evergreen (EG)	Plantation Forest (P)	185	2010
Coniferous Forest (CF)	Plantation Forest (P)	32	2010
Mixed Coniferous and Broadleaved (MCB)	Plantation Forest (P)	16	2010
Mixed Deciduous (MD)	Plantation Forest (P)	1,549	2005
Dry Dipterocarp (DD)	Plantation Forest (P)	17	2005
Bamboo (B)	Bamboo (B)	60,255	NA
Regenerating Vegetation (RV)	Bamboo (B)	177	2022
Mixed Deciduous (MD)	Bamboo (B)	21	2022
Mixed Deciduous (MD)	Bamboo (B)	388	2019
Evergreen (EG)	Bamboo (B)	11	2019
Dry Dipterocarp (DD)	Bamboo (B)	8	2019
Mixed Deciduous (MD)	Bamboo (B)	36	2015
Mixed Deciduous (MD)	Bamboo (B)	10,498	2010
Evergreen (EG)	Bamboo (B)	6	2010
Mixed Deciduous (MD)	Bamboo (B)	4,771	2005
Regenerating Vegetation (RV)	Regenerating Vegetation (RV)	4,145,463	NA
Mixed Deciduous (MD)	Regenerating Vegetation (RV)	265,312	2022
Evergreen (EG)	Regenerating Vegetation (RV)	22,029	2022
Plantation Forest (P)	Regenerating Vegetation (RV)	5,601	2022
Bamboo (B)	Regenerating Vegetation (RV)	4,380	2022
Dry Dipterocarp (DD)	Regenerating Vegetation (RV)	2,447	2022
Coniferous Forest (CF)	Regenerating Vegetation (RV)	631	2022
Mixed Coniferous and Broadleaved (MCB)	Regenerating Vegetation (RV)	477	2022
Mixed Deciduous (MD)	Regenerating Vegetation (RV)	161,350	2019
Evergreen (EG)	Regenerating Vegetation (RV)	2,424	2019
Dry Dipterocarp (DD)	Regenerating Vegetation (RV)	2,409	2019
Coniferous Forest (CF)	Regenerating Vegetation (RV)	530	2019
Mixed Coniferous and Broadleaved (MCB)	Regenerating Vegetation (RV)	411	2019
Mixed Deciduous (MD)	Regenerating Vegetation (RV)	272,089	2015
Evergreen (EG)	Regenerating Vegetation (RV)	825	2015

Dry Dipterocarp (DD)	Regenerating Vegetation (RV)	540	2015
Mixed Coniferous and Broadleaved (MCB)	Regenerating Vegetation (RV)	98	2015
Coniferous Forest (CF)	Regenerating Vegetation (RV)	58	2015
Mixed Deciduous (MD)	Regenerating Vegetation (RV)	172,818	2010
Mixed Coniferous and Broadleaved (MCB)	Regenerating Vegetation (RV)	10,181	2010
Coniferous Forest (CF)	Regenerating Vegetation (RV)	8,617	2010
Dry Dipterocarp (DD)	Regenerating Vegetation (RV)	4,857	2010
Evergreen (EG)	Regenerating Vegetation (RV)	886	2010
Mixed Deciduous (MD)	Regenerating Vegetation (RV)	95,037	2005
Dry Dipterocarp (DD)	Regenerating Vegetation (RV)	1,645	2005
Evergreen (EG)	Regenerating Vegetation (RV)	341	2005
Mixed Coniferous and Broadleaved (MCB)	Regenerating Vegetation (RV)	110	2005
Coniferous Forest (CF)	Regenerating Vegetation (RV)	1	2005

d). Emission Factors (EFs)/Parameter

- Since Lao PDR has not had the country-specific estimates of activity data and emission/removal, Tier 1 approach has been applied

6.3.3. 2. Land Converted to Forest Land (3B1.b)

The estimation of emissions and removals of greenhouse gases, which occur on lands converted to forest land from different land uses, including cropland, grassland, wetland, settlement, and other land, through afforestation and reforestation by natural or artificial regeneration (including plantation). The anthropogenic conversion includes promotion of natural regrowth by improving the water balance of soil by drainage, establishment of plantations on non-forest lands or previously unmanaged forest land, lands of settlements and industrial sites, and abandonment of croplands, pastures, or other managed lands that re-grow to forest. Unmanaged forests are not considered anthropogenic greenhouse gas sources or sinks and are excluded from inventory calculations (2006 IPCC Guideline, Chapter 4, Page 4.29).

a). Methodology

The estimation of emissions and removals of carbon from land-use conversion to forest land based on changes in carbon stocks is as follows:

- Annual Change in carbon stocks in Biomass (above-and below-ground Biomass);
- Annual Change in carbon stocks in Dead Organic Matter (dead wood and litter);
- Annual Change in Carbon Stocks in Soils.

Carbon Stock Change in Biomass

- Annual increase in carbon stocks in biomass will be applied regarding to Equation 2.9 in Chapter;
- A distinction between intensively (e.g., plantation forestry) and extensively (naturally re-growing stands with reduced or minimum human intervention) managed forest as the growth rate of trees strongly replies on management regime;
- Annual decrease in carbon stock in biomass due to wood removal, fuelwood removal, and disturbances attributed to Land Converted to Forest Land, is estimated applying Equation 2.11 in Chapter 2.

Carbon Stock Change in Dead Organic Matter (DOM)

- Tier 1 assumption is that carbon stocks in dead wood and litter pools in non-forest land are zero, and that carbon in dead organic matter pools increase linearly to the value of mature forest over a specified time period (default = 20 years);

- The dead organic matter carbon stocks in unmanaged forest are similar to managed forest;
- Based on the assumption of the Tier 1, the dead wood and litter pools increase linearly from zero (in the forest land-use category) to the default values for the climate region over a period of T years (the current default is 20 years for both litter and dead wood carbon pools).

Carbon Stock Change in Soil Carbon

- Change in soil organic Carbon stocks can be estimated for mineral soils with land-use conversion to Forest Land using Equation 2.25 (Chapter 2);
- Land Converted to Forest Land on organic soils within the inventory time period is treated the same as Forest Land Remaining Forest Land on organic soils. Carbon losses for the newly converted Forest Land are computed using Equation 2.26 (Chapter 2) if the soils are drained.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data (AD)

The activity data for estimating annual growth of biomass in carbon stocks from land converted to forest land includes as below:

- Areas of land converted to forest over the 20 years prior to the inventory year;
- Annual wood removal;
- Annual volume of fuelwood removal of whole trees;
- Annual volume of fuelwood removal as tree parts;
- Area affected by disturbance
- Rice paddy/Other Agriculture (RP/OA).
- Areas forest land converted to forestland;
- Area of grassland converted to forestland;
- Area of settlement converted to forestland;
- Area of Other converted to forestland;
- Area of wetland converted to forestland.

The detailed of the data for estimation emissions and removal of the land converted forest land are shown in (Table 76).

Table 76: Land Converted to Forest Land Areas between 2005-2022

Initial Land Use	Land Type in Reporting Year	Area (ha)	Year of Conversion
Rice Paddy/Other Agriculture (RP/OA)	Evergreen (EG)	56	2022
Rice Paddy/Other Agriculture (RP/OA)	Mixed Deciduous (MD)	3,116	2022
Upland Crop (UC)	Mixed Deciduous (MD)	954	2022
Urban Area (U)	Mixed Deciduous (MD)	17	2022
Agricultural Plantation (AP)	Mixed Deciduous (MD)	12	2022
Unmanaged River-Water	Mixed Deciduous (MD)	5	2022
Grassland (G)	Mixed Deciduous (MD)	3	2022
Unmanaged Barren Land & Rock (BR)	Mixed Deciduous (MD)	1	2022
Grassland (G)	Coniferous Forest (CF)	16	2022
Upland Crop (UC)	Coniferous Forest (CF)	2	2022

Upland Crop (UC)	Mixed Coniferous and Broadleaved (MCB)	46	2022
Rice Paddy/Other Agriculture (RP/OA)	Dry Dipterocarp (DD)	136	2022
Savannah (SA)	Dry Dipterocarp (DD)	32	2022
Upland Crop (UC)	Dry Dipterocarp (DD)	6	2022
Rice Paddy/Other Agriculture (RP/OA)	Plantation Forest (P)	18,342	2022
Agricultural Plantation (AP)	Plantation Forest (P)	7,681	2022
Upland Crop (UC)	Plantation Forest (P)	7,054	2022
Savannah (SA)	Plantation Forest (P)	134	2022
Unmanaged Other Land	Plantation Forest (P)	85	2022
Unmanaged Barren Land & Rock (BR)	Plantation Forest (P)	33	2022
Grassland (G)	Plantation Forest (P)	20	2022
Unmanaged River-Water	Plantation Forest (P)	17	2022
Urban Area (U)	Plantation Forest (P)	13	2022
Unspecified Wetland	Plantation Forest (P)	6	2022
Scrub (SR)	Plantation Forest (P)	5	2022
Rice Paddy/Other Agriculture (RP/OA)	Plantation Forest (P)	27,518	2019
Upland Crop (UC)	Plantation Forest (P)	2,292	2019
Agricultural Plantation (AP)	Plantation Forest (P)	721	2019
Savannah (SA)	Plantation Forest (P)	254	2019
Unmanaged Other Land	Plantation Forest (P)	184	2019
Grassland (G)	Plantation Forest (P)	83	2019
Unspecified Wetland	Plantation Forest (P)	6	2019
Urban Area (U)	Plantation Forest (P)	2	2019
Scrub (SR)	Plantation Forest (P)	1	2019
Rice Paddy/Other Agriculture (RP/OA)	Plantation Forest (P)	2,368	2015
Unspecified Wetland	Plantation Forest (P)	334	2015
Savannah (SA)	Plantation Forest (P)	233	2015
Agricultural Plantation (AP)	Plantation Forest (P)	104	2015
Unmanaged Other Land	Plantation Forest (P)	23	2015
Urban Area (U)	Plantation Forest (P)	16	2015
Scrub (SR)	Plantation Forest (P)	4	2015
Rice Paddy/Other Agriculture (RP/OA)	Plantation Forest (P)	6,451	2010
Grassland (G)	Plantation Forest (P)	4,131	2010
Agricultural Plantation (AP)	Plantation Forest (P)	1,628	2010
Scrub (SR)	Plantation Forest (P)	198	2010
Unspecified Wetland	Plantation Forest (P)	89	2010
Savannah (SA)	Plantation Forest (P)	79	2010
Grassland (G)	Plantation Forest (P)	139	2005
Rice Paddy/Other Agriculture (RP/OA)	Plantation Forest (P)	105	2005
Unspecified Wetland	Plantation Forest (P)	63	2005
Unmanaged Other Land	Plantation Forest (P)	16	2005
Savannah (SA)	Plantation Forest (P)	3	2005
Upland Crop (UC)	Bamboo (B)	273	2022
Rice Paddy/Other Agriculture (RP/OA)	Bamboo (B)	3	2022
Agricultural Plantation (AP)	Bamboo (B)	1	2022
Upland Crop (UC)	Bamboo (B)	723	2019
Rice Paddy/Other Agriculture (RP/OA)	Bamboo (B)	269	2019
Upland Crop (UC)	Bamboo (B)	21	2015
Rice Paddy/Other Agriculture (RP/OA)	Bamboo (B)	1	2015
Upland Crop (UC)	Bamboo (B)	1,299	2010
Rice Paddy/Other Agriculture (RP/OA)	Bamboo (B)	92	2010
Upland Crop (UC)	Bamboo (B)	273	2005
Rice Paddy/Other Agriculture (RP/OA)	Bamboo (B)	6	2005
Upland Crop (UC)	Regenerating Vegetation (RV)	82,348	2022
Rice Paddy/Other Agriculture (RP/OA)	Regenerating Vegetation (RV)	45,635	2022

Agricultural Plantation (AP)	Regenerating Vegetation (RV)	2,531	2022
Grassland (G)	Regenerating Vegetation (RV)	909	2022
Unmanaged River-Water	Regenerating Vegetation (RV)	481	2022
Savannah (SA)	Regenerating Vegetation (RV)	301	2022
Unmanaged Other Land	Regenerating Vegetation (RV)	145	2022
Unmanaged Barren Land & Rock (BR)	Regenerating Vegetation (RV)	76	2022
Urban Area (U)	Regenerating Vegetation (RV)	29	2022
Scrub (SR)	Regenerating Vegetation (RV)	11	2022
Unspecified Wetland	Regenerating Vegetation (RV)	4	2022
Upland Crop (UC)	Regenerating Vegetation (RV)	97,018	2019
Rice Paddy/Other Agriculture (RP/OA)	Regenerating Vegetation (RV)	23,455	2019
Unmanaged Other Land	Regenerating Vegetation (RV)	1,833	2019
Agricultural Plantation (AP)	Regenerating Vegetation (RV)	990	2019
Urban Area (U)	Regenerating Vegetation (RV)	252	2019
Scrub (SR)	Regenerating Vegetation (RV)	1	2019
Upland Crop (UC)	Regenerating Vegetation (RV)	204,505	2015
Rice Paddy/Other Agriculture (RP/OA)	Regenerating Vegetation (RV)	49,881	2015
Agricultural Plantation (AP)	Regenerating Vegetation (RV)	1,670	2015
Unmanaged Other Land	Regenerating Vegetation (RV)	279	2015
Urban Area (U)	Regenerating Vegetation (RV)	182	2015
Upland Crop (UC)	Regenerating Vegetation (RV)	205,761	2010
Rice Paddy/Other Agriculture (RP/OA)	Regenerating Vegetation (RV)	55,129	2010
Agricultural Plantation (AP)	Regenerating Vegetation (RV)	1,985	2010
Unmanaged Other Land	Regenerating Vegetation (RV)	131	2010
Urban Area (U)	Regenerating Vegetation (RV)	65	2010
Grassland (G)	Regenerating Vegetation (RV)	43	2010
Upland Crop (UC)	Regenerating Vegetation (RV)	190,559	2005
Rice Paddy/Other Agriculture (RP/OA)	Regenerating Vegetation (RV)	16,566	2005
Agricultural Plantation (AP)	Regenerating Vegetation (RV)	1,724	2005
Unmanaged Other Land	Regenerating Vegetation (RV)	205	2005
Urban Area (U)	Regenerating Vegetation (RV)	90	2005

d). Emission Factor and Parameter

Since Lao PDR has not had the country-specific estimates of activity data and emission/removal, Tier 1 approach has been applied.

6.3.4. Cropland (3B2)

Cropland includes arable and tillable Land, rice fields, and agroforestry systems where the vegetation structure falls below the thresholds used for the Forest Land category. It also includes all annual crops (rice, vegetables, root crops, and forages), perennial crops (trees and shrubs), and temporary fallows land. The amount of carbon stored in, emitted, or removed from permanent Cropland depends on crop type, management practices, soil, and climate variables. For example, annual crops (rice and vegetables) are harvested yearly, so there is no long-term carbon storage in biomass. However, perennial woody vegetables in trees and shrubs can store significant carbon in long-lived biomass depending on species type and cultivar, density, growth rates, and harvesting (IPCC Guideline 2006, Chapter 5, Page 5.6). The Cropland covers Cropland remaining Cropland and the Land converted Cropland. The greenhouse gas (GHG) emissions and removal from Cropland for 2022 are shown in

6.3.4.1. Cropland Remaining Cropland (3B2.a)

a). Methodology

The estimation annual greenhouse gas emission and removal from Cropland Remaining Cropland include: Annual change in Carbon stocks from all Carbon pools and sources and Annual emission of non- CO_2 gases from all pools and sources.

Carbon Stock Change in Biomass

- Changes in Carbon in Cropland biomass can be estimated from annual rates of biomass gain and loss (Chapter 2, Equation 2.7);
- Estimate Gain used the 2006 IPCC Guidelines, Chapter 2, Volume 4, Equation 2.9;
- Estimate Loss used 2006 IPCC Guidelines, Chapter 2, Volume 4, Equation 2.11;

Carbon Stock Change in Dead Organic Matter (DOM)

- The method for estimating Carbon Stock changes in dead organic matter includes dead wood and litter;
- The Tier 1 method assumes that the dead wood and litter stocks are not present in Cropland or are at Equilibrium due to in agroforestry and orchards. Thus, there is no need to estimate the carbon stocks changes for theses pools;
- The assumption in Tier 1 is that the DOM carbon stocks in all Cropland Remaining Cropland are insignificant or are not changing. Hence, no emission/removal factors and activity data are needed.

Carbon Stock Change in Soil Carbon

- The estimation of mineral soil is based on change in soil organic C stocks over a finite period following changes in management that impact soil organic Carbon;
- Equation 2.24, IPCC 2006 Guidelines, Chapter 2 is used to estimate Carbon stock in soil, including changes in mineral soil, organic soil, and inorganic Carbon in soil;
- Equation 2.25, IPCC 2006 Guidelines, Chapter 2 is used to estimate change in soil organic C stocks in mineral soils.
- Equation 2.26, IPCC 2006 Guidelines, Chapter 2 is used to estimate Carbon stock change in organic soils.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data (DA)

The activity data for estimating greenhouse gas emission and removal in Crop Remaining Cropland include:

- Area of perennial crops that is removed or harvested in the year (ha);
- Upland crop (UC);
- Agriculture plantation (AP);
- Rice paddy/Other Agriculture (RP/OA).

The gathered data for estimation emission and removal of the Cropland Remaining Cropland is shown in (Table 77).

Table 77: Cropland Remaining Cropland Areas between 2005 - 2022

Initial Land Use	Land Type in Reporting Year	Area (ha)	Year of Conversion
Rice Paddy and Other Agricultures (RP/OA)	Upland Crop (UC)	1,734	2022
Agricultural Plantation (AP)	Upland Crop (UC)	135	2022
Agricultural Plantation (AP)	Agricultural Plantation (AP)	14,072	NA
Rice Paddy and Other Agricultures (RP/OA)	Agricultural Plantation (AP)	1,013	2022
Upland Crop (UC)	Agricultural Plantation (AP)	755	2022
Rice Paddy and Other Agricultures (RP/OA)	Agricultural Plantation (AP)	4,796	2019
Upland Crop (UC)	Agricultural Plantation (AP)	95	2019
Rice Paddy and Other Agricultures (RP/OA)	Agricultural Plantation (AP)	459	2015
Upland Crop (UC)	Agricultural Plantation (AP)	32	2015
Rice Paddy and Other Agricultures (RP/OA)	Agricultural Plantation (AP)	6,451	2010
Rice Paddy and Other Agricultures (RP/OA)	Agricultural Plantation (AP)	790	2005
Rice Paddy and Other Agricultures (RP/OA)	Rice Paddy and Other Agricultures (RP/OA)	1,260,568	NA
Upland Crop (UC)	Rice Paddy and Other Agricultures (RP/OA)	29,211	2022
Agricultural Plantation (AP)	Rice Paddy and Other Agricultures (RP/OA)	1,520	2022
Upland Crop (UC)	Rice Paddy and Other Agricultures (RP/OA)	49,499	2019
Agricultural Plantation (AP)	Rice Paddy and Other Agricultures (RP/OA)	637	2019
Agricultural Plantation (AP)	Rice Paddy and Other Agricultures (RP/OA)	1,252	2015
Agricultural Plantation (AP)	Rice Paddy and Other Agricultures (RP/OA)	31	2010
Agricultural Plantation (AP)	Rice Paddy and Other Agricultures (RP/OA)	5	2005

d). Emission Factor

Since Lao PDR has not had the country-specific estimates emission/removal of Cropland Remaining Cropland, Tier 1 approach has been applied.

6.3.4.2. Land Converted to Cropland (3B2.b)

a). Methods

Estimation of annual greenhouse gas emissions and removals from Land Converted to Cropland includes the change in Carbon stocks from all Carbon pools and sources as follows:

- Biomass (above-ground and below-ground biomass);
- Dead organic matter (dead wood and litter);
- Soil (soil organic matter).

Carbon Stock Change in Biomass

- Annual increase or gain in carbon stocks in biomass due to land converted to another land-use category can be estimated using Equation 2.9 (2006 IPCC Guidelines, Chapter 2, page 2.19);

- Annual decrease or loss in Carbon stocks in biomass due to losses on converted land (wood removals, fuelwood collection, and disturbances) can be estimated using Equation 2.11 to 2.14 (2006 IPCC Guidelines, Chapter 2, page 2.19).

Carbon Stock Change in Dead Organic Matter (DOM)

- Tier 1 assumption for land converted from forest to another land-use category is that all DOM carbon losses occur in the yar of land-use conversion. Conversely, conversion to forest land result in build-up of litter and dead wood carbon pools starting from zero carbon in those pools (2006 IPCC Guidelines, Chapter 2, page 2.25);
- DOM carbon gains on land converted to forest occur linearly, starting from zero, over a transition period (default assumption is 20 years) (2006 IPCC Guidelines, Chapter 2, page 2.25).

Carbon Stock Change in Soil Carbon

- The total change in soil Carbon stocks for Land Converted to Cropland is estimated using Equation 2.24 (2006 IPCC Guidelines, Chapter 2, Volume 4, Page 2.29)

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data (AD)

The activity data for estimating greenhouse gas emission and removal in Land converted Cropland include:

- Area of perennial crops that is removed or harvested in the year (ha);
- Upland crop (UC);
- Agriculture plantation (AP);
- Rice paddy/Other Agriculture (RP/OA).
- Areas forest land converted to cropland;
- Area of grassland converted to cropland;
- Area of settlement converted to cropland;
- Area of Other converted to cropland;
- Area of wetland converted to cropland.

The gathered data for estimation emission and removal of the Land Converted to Cropland is shown in Table (78).

Table 78: Land Converted to Cropland between 2005-2022

Initial Land Use	Land Type in Reporting Year	Area (ha)	Year of Conversion
Regenerating Vegetation (RV)	Upland Crop (UC)	105,259	2022
Mixed Deciduous (MD)	Upland Crop (UC)	17,069	2022
Evergreen (EG)	Upland Crop (UC)	3,130	2022
Bamboo (B)	Upland Crop (UC)	739	2022
Plantation Forest (P)	Upland Crop (UC)	438	2022
Dry Dipterocarp (DD)	Upland Crop (UC)	433	2022
Coniferous Forest (CF)	Upland Crop (UC)	256	2022
Grassland (G)	Upland Crop (UC)	174	2022
Mixed Coniferous and Broadleaved (MCB)	Upland Crop (UC)	110	2022

Savannah (SA)	Upland Crop (UC)	107	2022
Unmanaged River-Water	Upland Crop (UC)	41	2022
Unmanaged Other Land	Upland Crop (UC)	29	2022
Unmanaged Barren Land & Rock (BR)	Upland Crop (UC)	9	2022
Urban Area (U)	Upland Crop (UC)	8	2022
Scrub (SR)	Upland Crop (UC)	2	2022
Regenerating Vegetation (RV)	Upland Crop (UC)	8,245	2019
Regenerating Vegetation (RV)	Agricultural Plantation (AP)	698	2022
Mixed Deciduous (MD)	Agricultural Plantation (AP)	531	2022
Plantation Forest (P)	Agricultural Plantation (AP)	152	2022
Dry Dipterocarp (DD)	Agricultural Plantation (AP)	55	2022
Evergreen (EG)	Agricultural Plantation (AP)	23	2022
Grassland (G)	Agricultural Plantation (AP)	8	2022
Unspecified Wetland	Agricultural Plantation (AP)	2	2022
Mixed Coniferous and Broadleaved (MCB)	Agricultural Plantation (AP)	1	2022
Savannah (SA)	Agricultural Plantation (AP)	1	2022
Unmanaged River-Water	Agricultural Plantation (AP)	1	2022
Regenerating Vegetation (RV)	Agricultural Plantation (AP)	6,653	2019
Mixed Deciduous (MD)	Agricultural Plantation (AP)	1,871	2019
Plantation Forest (P)	Agricultural Plantation (AP)	337	2019
Dry Dipterocarp (DD)	Agricultural Plantation (AP)	233	2019
Evergreen (EG)	Agricultural Plantation (AP)	143	2019
Unmanaged Other Land	Agricultural Plantation (AP)	17	2019
Grassland (G)	Agricultural Plantation (AP)	11	2019
Bamboo (B)	Agricultural Plantation (AP)	10	2019
Savannah (SA)	Agricultural Plantation (AP)	1	2019
Mixed Deciduous (MD)	Agricultural Plantation (AP)	2,200	2015
Dry Dipterocarp (DD)	Agricultural Plantation (AP)	1,364	2015
Regenerating Vegetation (RV)	Agricultural Plantation (AP)	929	2015
Savannah (SA)	Agricultural Plantation (AP)	94	2015
Plantation Forest (P)	Agricultural Plantation (AP)	28	2015
Unmanaged Other Land	Agricultural Plantation (AP)	3	2015
Evergreen (EG)	Agricultural Plantation (AP)	1	2015
Unspecified Wetland	Agricultural Plantation (AP)	1	2015
Regenerating Vegetation (RV)	Agricultural Plantation (AP)	19,216	2010
Mixed Deciduous (MD)	Agricultural Plantation (AP)	4,153	2010
Dry Dipterocarp (DD)	Agricultural Plantation (AP)	2,854	2010
Grassland (G)	Agricultural Plantation (AP)	413	2010
Savannah (SA)	Agricultural Plantation (AP)	115	2010
Plantation Forest (P)	Agricultural Plantation (AP)	66	2010
Unspecified Wetland	Agricultural Plantation (AP)	23	2010
Evergreen (EG)	Agricultural Plantation (AP)	21	2010
Coniferous Forest (CF)	Agricultural Plantation (AP)	5	2010
Scrub (SR)	Agricultural Plantation (AP)	5	2010
Mixed Coniferous and Broadleaved (MCB)	Agricultural Plantation (AP)	4	2010
Unmanaged Other Land	Agricultural Plantation (AP)	1	2010
Regenerating Vegetation (RV)	Agricultural Plantation (AP)	2,659	2005
Mixed Deciduous (MD)	Agricultural Plantation (AP)	913	2005
Grassland (G)	Agricultural Plantation (AP)	71	2005
Savannah (SA)	Agricultural Plantation (AP)	26	2005
Dry Dipterocarp (DD)	Agricultural Plantation (AP)	20	2005
Unspecified Wetland	Agricultural Plantation (AP)	20	2005
Evergreen (EG)	Agricultural Plantation (AP)	4	2005
Regenerating Vegetation (RV)	Rice Paddy and Other Agricultures (RP/OA)	24,314	2022

Mixed Deciduous (MD)	Rice Paddy and Other Agricultures (RP/OA)	23,077	2022
Dry Dipterocarp (DD)	Rice Paddy and Other Agricultures (RP/OA)	7,364	2022
Evergreen (EG)	Rice Paddy and Other Agricultures (RP/OA)	3,959	2022
Plantation Forest (P)	Rice Paddy and Other Agricultures (RP/OA)	3,764	2022
Savannah (SA)	Rice Paddy and Other Agricultures (RP/OA)	406	2022
Bamboo (B)	Rice Paddy and Other Agricultures (RP/OA)	369	2022
Grassland (G)	Rice Paddy and Other Agricultures (RP/OA)	313	2022
Unmanaged River-Water	Rice Paddy and Other Agricultures (RP/OA)	170	2022
Coniferous Forest (CF)	Rice Paddy and Other Agricultures (RP/OA)	85	2022
Unmanaged Other Land	Rice Paddy and Other Agricultures (RP/OA)	70	2022
Unmanaged Barren Land & Rock (BR)	Rice Paddy and Other Agricultures (RP/OA)	64	2022
Urban Area (U)	Rice Paddy and Other Agricultures (RP/OA)	43	2022
Mixed Coniferous and Broadleaved (MCB)	Rice Paddy and Other Agricultures (RP/OA)	37	2022
Unspecified Wetland	Rice Paddy and Other Agricultures (RP/OA)	6	2022
Scrub (SR)	Rice Paddy and Other Agricultures (RP/OA)	1	2022
Mixed Deciduous (MD)	Rice Paddy and Other Agricultures (RP/OA)	47,135	2019
Regenerating Vegetation (RV)	Rice Paddy and Other Agricultures (RP/OA)	40,475	2019
Savannah (SA)	Rice Paddy and Other Agricultures (RP/OA)	31,541	2019
Dry Dipterocarp (DD)	Rice Paddy and Other Agricultures (RP/OA)	9,126	2019
Unmanaged Other Land	Rice Paddy and Other Agricultures (RP/OA)	8,152	2019
Plantation Forest (P)	Rice Paddy and Other Agricultures (RP/OA)	6,979	2019
Grassland (G)	Rice Paddy and Other Agricultures (RP/OA)	3,622	2019
Unspecified Wetland	Rice Paddy and Other Agricultures (RP/OA)	3,329	2019
Bamboo (B)	Rice Paddy and Other Agricultures (RP/OA)	862	2019
Evergreen (EG)	Rice Paddy and Other Agricultures (RP/OA)	330	2019
Scrub (SR)	Rice Paddy and Other Agricultures (RP/OA)	236	2019
Coniferous Forest (CF)	Rice Paddy and Other Agricultures (RP/OA)	117	2019
Unmanaged River-Water	Rice Paddy and Other Agricultures (RP/OA)	82	2019
Urban Area (U)	Rice Paddy and Other Agricultures (RP/OA)	74	2019
Mixed Coniferous and Broadleaved (MCB)	Rice Paddy and Other Agricultures (RP/OA)	57	2019
Regenerating Vegetation (RV)	Rice Paddy and Other Agricultures (RP/OA)	87,174	2015
Mixed Deciduous (MD)	Rice Paddy and Other Agricultures (RP/OA)	55,462	2015
Dry Dipterocarp (DD)	Rice Paddy and Other Agricultures (RP/OA)	9,244	2015
Evergreen (EG)	Rice Paddy and Other Agricultures (RP/OA)	3,360	2015
Bamboo (B)	Rice Paddy and Other Agricultures (RP/OA)	1,045	2015
Grassland (G)	Rice Paddy and Other Agricultures (RP/OA)	975	2015
Plantation Forest (P)	Rice Paddy and Other Agricultures (RP/OA)	913	2015
Savannah (SA)	Rice Paddy and Other Agricultures (RP/OA)	786	2015
Urban Area (U)	Rice Paddy and Other Agricultures (RP/OA)	424	2015
Unmanaged River-Water	Rice Paddy and Other Agricultures (RP/OA)	387	2015
Unmanaged Other Land	Rice Paddy and Other Agricultures (RP/OA)	349	2015
Mixed Coniferous and Broadleaved (MCB)	Rice Paddy and Other Agricultures (RP/OA)	268	2015
Coniferous Forest (CF)	Rice Paddy and Other Agricultures (RP/OA)	158	2015
Scrub (SR)	Rice Paddy and Other Agricultures (RP/OA)	45	2015
Unspecified Wetland	Rice Paddy and Other Agricultures (RP/OA)	22	2015
Regenerating Vegetation (RV)	Rice Paddy and Other Agricultures (RP/OA)	350,393	2010
Mixed Deciduous (MD)	Rice Paddy and Other Agricultures (RP/OA)	51,927	2010
Dry Dipterocarp (DD)	Rice Paddy and Other Agricultures (RP/OA)	27,367	2010
Grassland (G)	Rice Paddy and Other Agricultures (RP/OA)	2,878	2010
Savannah (SA)	Rice Paddy and Other Agricultures (RP/OA)	1,986	2010
Evergreen (EG)	Rice Paddy and Other Agricultures (RP/OA)	1,439	2010
Scrub (SR)	Rice Paddy and Other Agricultures (RP/OA)	490	2010
Unspecified Wetland	Rice Paddy and Other Agricultures (RP/OA)	408	2010

Mixed Coniferous and Broadleaved (MCB)	Rice Paddy and Other Agricultures (RP/OA)	381	2010
Plantation Forest (P)	Rice Paddy and Other Agricultures (RP/OA)	381	2010
Coniferous Forest (CF)	Rice Paddy and Other Agricultures (RP/OA)	221	2010
Bamboo (B)	Rice Paddy and Other Agricultures (RP/OA)	117	2010
Unmanaged Other Land	Rice Paddy and Other Agricultures (RP/OA)	15	2010
Unmanaged River-Water	Rice Paddy and Other Agricultures (RP/OA)	2	2010
Regenerating Vegetation (RV)	Rice Paddy and Other Agricultures (RP/OA)	203,981	2005
Mixed Deciduous (MD)	Rice Paddy and Other Agricultures (RP/OA)	28,344	2005
Dry Dipterocarp (DD)	Rice Paddy and Other Agricultures (RP/OA)	7,577	2005
Grassland (G)	Rice Paddy and Other Agricultures (RP/OA)	2,655	2005
Savannah (SA)	Rice Paddy and Other Agricultures (RP/OA)	1,022	2005
Bamboo (B)	Rice Paddy and Other Agricultures (RP/OA)	488	2005
Unspecified Wetland	Rice Paddy and Other Agricultures (RP/OA)	374	2005
Evergreen (EG)	Rice Paddy and Other Agricultures (RP/OA)	217	2005
Mixed Coniferous and Broadleaved (MCB)	Rice Paddy and Other Agricultures (RP/OA)	76	2005
Unmanaged Other Land	Rice Paddy and Other Agricultures (RP/OA)	17	2005
Unmanaged River-Water	Rice Paddy and Other Agricultures (RP/OA)	17	2005
Urban Area (U)	Rice Paddy and Other Agricultures (RP/OA)	5	2005
Coniferous Forest (CF)	Rice Paddy and Other Agricultures (RP/OA)	4	2005
Plantation Forest (P)	Rice Paddy and Other Agricultures (RP/OA)	2	2005
Scrub (SR)	Rice Paddy and Other Agricultures (RP/OA)	2	2005

d). Emission Factor

Since Lao PDR has not had the country-specific estimates emission/removal of Land converted to Cropland, Tier 1 approach has been applied.

6.3.5. Grassland (3.B.3)

6.3.5.1 Grassland Remaining Grassland (3B3.a)

Grassland Remaining Grassland encompass pastures which have always been under grassland vegetation and pasture use or other land categories converted to grassland more than 20 years ago. The estimation of grassland involves in change carbon stock from five carbon pools:

- Above-ground biomass;
- Below-ground biomass;
- Dead wood;
- Litter;
- Soil organic matter

a). Methodology

- Estimation of change in carbon stock in biomass requires an estimate of change in stocks of above-ground biomass and changes in carbon stocks in below-ground biomass;
- The carbon stock of Grassland where there is no change in either type or intensity of management, biomass is approximate steady-state (i.e., carbon accumulation through plants growth is approximately balanced by losses through grazing, decomposition and fire). Conversely, where manage change in Grassland are occurring over time (e.g., tree/brush removal for grazing management, improved pasture management or other practice), the carbon stock change can be significant.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.
Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion

of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

The activity data for Grassland Remaining Grassland includes:

- Area of Savannha (SA)
- Area of Scrub (SR)
- Area of Grassland (G)

The data gathered for estimating the emission and removal of the Grassland Remaining Grassland is shown in (Table 79).

Table 79: Grassland Remaining Grassland between 2005-2022

Initial Land Use	Land Type in Reporting Year	Area (ha)	Year of Conversion
Savannah (SA)	Savannah (SA)	68,164	NA
Scrub (SR)	Scrub (SR)	25,701	NA
Grassland (G)	Grassland (G)	247,153	NA
Scrub (SR)	Grassland (G)	2	2010
Scrub (SR)	Grassland (G)	160	2005

d). Emission Factor

Since Lao PDR has not had the country-specific estimates emission/removal of the Grassland Remaining Grassland, Tier 1 approach is used.

6.3.5.2 Land Converted to Grassland (3B3.b)

Land Converted to Grassland comprises Forest Land or Other land-use categories converted to Grassland with the last 20 years. This inventory involves in estimation of change in carbon stock as below:

- Above-ground biomass;
- Below-ground biomass;
- Dead wood;
- Litter;
- Soil organic matter

a). Methodology

- Estimate of change in biomass requires an estimate of changes in above-ground vegetation and
  changes in below-ground biomass;
- The change in biomass carbon stock on Land Converted to Grassland used Equation 2.15 (IPCC 2006 Guideline, Chapter 2, Volume 2, Page 2.20).

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

The activity data for estimation the emission and removal for Land Converted Grassland includes:

- Area of Savannha (SA);

- Area of Scrub (SR);
- Area of Grassland (G);
- Area of Forest converted to Grassland;
- Area of Cropland converted Grassland;

The gathered data for estimation emission and removal of the Land Converted to Grassland is shown in (Table 80).

Table 80: Land Converted to Grassland between 2005-2022

Initial Land Use	Land Type in Reporting Year	Area (ha)	Year of Conversion
Dry Dipterocarp (DD)	Savannah (SA)	9	2022
Dry Dipterocarp (DD)	Savannah (SA)	49	2019
Dry Dipterocarp (DD)	Savannah (SA)	74	2015
Upland Crop (UC)	Savannah (SA)	5	2015
Upland Crop (UC)	Savannah (SA)	349	2010
Dry Dipterocarp (DD)	Savannah (SA)	104	2010
Upland Crop (UC)	Savannah (SA)	156	2005
Dry Dipterocarp (DD)	Savannah (SA)	26	2005
Mixed Deciduous (MD)	Scrub (SR)	1	2022
Upland Crop (UC)	Scrub (SR)	1	2022
Upland Crop (UC)	Scrub (SR)	21	2019
Dry Dipterocarp (DD)	Scrub (SR)	5	2019
Rice Paddy/Other Agriculture (RP/OA)	Scrub (SR)	26	2015
Unmanaged Barren Land & Rock (BR)	Scrub (SR)	6	2015
Upland Crop (UC)	Scrub (SR)	3	2015
Dry Dipterocarp (DD)	Scrub (SR)	99	2010
Upland Crop (UC)	Scrub (SR)	94	2010
Upland Crop (UC)	Scrub (SR)	374	2005
Unmanaged Barren Land & Rock (BR)	Scrub (SR)	24	2005
Upland Crop (UC)	Grassland (G)	248	2022
Regenerating Vegetation (RV)	Grassland (G)	23	2022
Plantation Forest (P)	Grassland (G)	20	2022
Mixed Coniferous and Broadleaved (MCB)	Grassland (G)	10	2022
Mixed Deciduous (MD)	Grassland (G)	7	2022
Agricultural Plantation (AP)	Grassland (G)	6	2022
Rice Paddy/Other Agriculture (RP/OA)	Grassland (G)	6	2022
Upland Crop (UC)	Grassland (G)	265	2019
Regenerating Vegetation (RV)	Grassland (G)	71	2019
Dry Dipterocarp (DD)	Grassland (G)	27	2019
Mixed Deciduous (MD)	Grassland (G)	22	2019
Regenerating Vegetation (RV)	Grassland (G)	107	2015
Mixed Deciduous (MD)	Grassland (G)	73	2015
Rice Paddy/Other Agriculture (RP/OA)	Grassland (G)	13	2015
Dry Dipterocarp (DD)	Grassland (G)	4	2015
Upland Crop (UC)	Grassland (G)	4	2015
Agricultural Plantation (AP)	Grassland (G)	2	2015
Coniferous Forest(CF)	Grassland (G)	2	2015
Upland Crop (UC)	Grassland (G)	321	2010
Regenerating Vegetation (RV)	Grassland (G)	7	2010
Regenerating Vegetation (RV)	Grassland (G)	547	2005
Upland Crop (UC)	Grassland (G)	224	2005
Mixed Deciduous (MD)	Grassland (G)	78	2005
Mixed Coniferous and Broadleaved (MCB)	Grassland (G)	40	2005

Coniferous Forest (CF)	Grassland (G)	28	2005
Dry Dipterocarp (DD)	Grassland (G)	11	2005

d). Emission Factor

Since Lao PDR has not had the country-specific estimates emission/removal of the Land Converted to Grassland, Tier 1 approach is used.

6.3.6. Wetlands (3.B.4)

Wetlands are any land that is covered or saturated by water for all or part of the year, and that not fall into the Forest land, Cropland, or Grassland categories. The estimation of CO_2 emission from wetland based on the sum of emission from the two types of managed wetland as follows. The Net emission from Wetland for 2022 are presented in (Table 81).

Table 81: Next Emission from Wetland for 2022

Categories	(Gg) Net CO_2 emissions / removals	Emissions	
		CH_4	N_2O
3.B4 – Wetlands			
3.B.1.a – Wetlands Remaining Wetlands		NE	NE
3.B.1.b- Land Converted to Wetlands	1.30	NE	NE

6.3.6. 1. Wetlands Remaining Wetlands

Based on the 2006 IPCC Guideline, the GHG emissions from wetland remaining wetlands is not required to report as there was no information emission from Wetlands remaining wetlands.

6.3.6.2. Land Converted to Wetlands

Land converted to wetlands found that only change in carbon stocks in living biomass was estimated.

a). Methodology

Equation 2.16, Page 2.20, Chapter 2, Volume 2, 2006 IPCC Guideline was used to estimate Change the living biomass carbon stocks of land converted to wetland.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

The activity data of Change in living biomass carbon stocks was an area of the land converted to wetland area and logging and disturbance information, occurring in Land converted to wetlands. The detail of activity data is presented in (Table 82)

Table 82: Activity Data for Wetlands

Initial Land Use	Land Type in Reporting Year	Area (ha)	Year of Conversion
Unspecified Wetland	Unspecified Wetland	5,729	NA
Upland Crop (UC)	Wetland-Swamp (SW)	50	2022
Rice Paddy/Other Agriculture (RP/OA)	Wetland-Swamp (SW)	21	2022
Regenerating Vegetation (RV)	Wetland-Swamp (SW)	2	2022
Upland Crop (UC)	Wetland-Swamp (SW)	133	2010
Upland Crop (UC)	Wetland-Swamp (SW)	185	2005
Unmanaged River-Water	Wetland-Swamp (SW)	8	2005

d). Emission Factor

The parameters applied for estimating emissions and removals from land converted to wetland

- Above-ground biomass of the land before conversion;
- Biomass of the land after conversion;
- Growth of biomass carbon in the year the conversion;

6.3.7. Settlements (3.B.5)

The emission was calculated from changes in carbon stocks in living biomass, DOM, and soil in land converted to settlements. Net emission from settlements for 2022 are presented in (Table 83)

Table 83: Net Emission from Settlements for 2022

Categories	Net CO_2 Emissions /Removals (Gg)	Emissions	
	CO_2	CH_4	N_2O
3.B.5. Settlements			
3.B.5.a. Settlements remaining settlements	0	NE	NE
3.B.5.b. Land converted to settlements	58.51	NE	NE

6.3.7.1. Settlements Remaining Settlements (3.B.5.a)

As lack of data in the country for the settlement's subsector, it was not change in carbon stocks in living biomass for estimation settlement remaining settlements.

6.3.7.2. Land Converted to Settlements (3.B.5.b)

The land converted to settlement was calculated carbon stocks change of living biomass and DOM.

a). Methodology

Changing the living biomass stock of land converted to settlements was calculated by applying Equation 2.16, Page 2.20, Chapter 2, Volume 2, the 2006 IPCC Guidelines.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

The activity data used on Forest land converted to settlement for 2022 is presented in (Table 84)

Table 84: Activity Data for Settlement Areas

Initial Land Use	Land Type in Reporting Year	Area (ha)	Year of Conversion
Urban Area (U)	Urban Area (U)	61,574	NA
Upland Crop (UC)	Urban Area (U)	1,826	2022
Mixed Deciduous (MD)	Urban Area (U)	516	2022
Regenerating Vegetation (RV)	Urban Area (U)	337	2022
Rice Paddy/Other Agriculture (RP/OA)	Urban Area (U)	300	2022
Dry Dipterocarp (DD)	Urban Area (U)	91	2022
Unmanaged Other Land	Urban Area (U)	20	2022
Scrub (SR)	Urban Area (U)	18	2022
Evergreen (EG)	Urban Area (U)	16	2022
Plantation Forest (P)	Urban Area (U)	8	2022
Savannah (SA)	Urban Area (U)	3	2022
Unmanaged River-Water	Urban Area (U)	3	2022
Agricultural Plantation (AP)	Urban Area (U)	2	2022
Rice Paddy/Other Agriculture (RP/OA)	Urban Area (U)	14636	2019
Regenerating Vegetation (RV)	Urban Area (U)	4472	2019
Dry Dipterocarp (DD)	Urban Area (U)	2434	2019
Mixed Deciduous (MD)	Urban Area (U)	2140	2019
Unmanaged Other Land	Urban Area (U)	1228	2019
Upland Crop (UC)	Urban Area (U)	310	2019
Savannah (SA)	Urban Area (U)	268	2019
Grassland (G)	Urban Area (U)	152	2019
Plantation Forest (P)	Urban Area (U)	126	2019
Evergreen (EG)	Urban Area (U)	60	2019
Unspecified Wetland	Urban Area (U)	9	2019
Bamboo (B)	Urban Area (U)	7	2019
Coniferous Forest(CF)	Urban Area (U)	1	2019
Agricultural Plantation (AP)	Urban Area (U)	1	2019
Regenerating Vegetation (RV)	Urban Area (U)	1060	2015
Rice Paddy/Other Agriculture (RP/OA)	Urban Area (U)	847	2015
Mixed Deciduous (MD)	Urban Area (U)	517	2015
Dry Dipterocarp (DD)	Urban Area (U)	323	2015
Upland Crop (UC)	Urban Area (U)	292	2015
Unmanaged Other Land	Urban Area (U)	47	2015
Savannah (SA)	Urban Area (U)	28	2015
Grassland (G)	Urban Area (U)	28	2015
Evergreen (EG)	Urban Area (U)	20	2015
Scrub (SR)	Urban Area (U)	12	2015
Agricultural Plantation (AP)	Urban Area (U)	9	2015
Plantation Forest (P)	Urban Area (U)	4	2015
Bamboo (B)	Urban Area (U)	3	2015
Rice Paddy/Other Agriculture (RP/OA)	Urban Area (U)	6379	2010
Regenerating Vegetation (RV)	Urban Area (U)	1463	2010
Dry Dipterocarp (DD)	Urban Area (U)	432	2010
Grassland (G)	Urban Area (U)	281	2010
Mixed Deciduous (MD)	Urban Area (U)	272	2010
Mixed Coniferous and Broadleaved (MCB)	Urban Area (U)	135	2010
Upland Crop (UC)	Urban Area (U)	65	2010
Savannah (SA)	Urban Area (U)	28	2010
Unspecified Wetland	Urban Area (U)	5	2010
Unmanaged Other Land	Urban Area (U)	430	2005
Rice Paddy/Other Agriculture (RP/OA)	Urban Area (U)	321	2005
Regenerating Vegetation (RV)	Urban Area (U)	201	2005

Upland Crop (UC)	Urban Area (U)	143	2005
Grassland (G)	Urban Area (U)	60	2005
Mixed Deciduous (MD)	Urban Area (U)	26	2005
Dry Dipterocarp (DD)	**Urban Area (U)**	**17**	**2005**

6.3.8. Other Land (3.B.6)

Net CO_2 emission for 2022 from other land was 3,010.10 Net GgCO_2 eq while net CO_2 emission from settlements remaining settlements was zero due to no change in living biomass carbon stocks (Table 85).

Table 85: Net CO2 Emission for 2022 from Other Land

Categories	**Net CO_2 emissions / removals (Gg)**	**Emissions**	
		CH_4	N_2O
3.B.6. Other Land			
3.B.5.a. Other land remaining other land	0	NE	NE
3.B.5.b. Land converted to other land	3,010.10	NE	NE

6.3.8.1. Other Land Remaining Other Land (3.B.6.a)

Carbon stock change in living biomass in other land remaining other land was zero because there was living biomass in other soils. Therefore, the emissions and removals from DOM and other soil in other land was not estimated on account of lack of data.

6.3.8.2. Land Converted to Other Land (3.B.6.b)

a). Methodology

The living biomass carbon stock change of land converted to other land was calibrated by applying Equation 2.16, Page 2.20, Chapter 2, Volume 4, 2006 IPCC Guideline.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

Carbon stock change in living biomass AD was the areas of the land converted to other land and logging and disturbance information, occurring in land converted to other land. The detail is presented in (Table 86).

Table 86: Other Land Remaining Other Land between 2005-2022

Initial Land Use	**Land Type in Reporting Year**	**Area (ha)**	**Year of Conversion**
Unmanaged Barren Land & Rock	Unmanaged Barren Land & Rock	185,315	NA
Unmanaged Other Land	Managed Barren & Rock (BR)	1	2019
Unmanaged Other Land	Managed Barren & Rock (BR)	137	2015
Unmanaged River-Water	Managed Barren & Rock (BR)	9	2015
Unmanaged River-Water	Managed Barren & Rock (BR)	93	2010
Unmanaged River-Water	Managed Barren & Rock (BR)	131	2005
Unmanaged River-Water	Unmanaged River-Water	274,007	NA

Unmanaged Other Land	Managed River-Water (W)	26	2022
Unmanaged Barren Land & Rock	Managed River-Water (W)	7	2022
Unmanaged Other Land	Managed River-Water (W)	730	2019
Unmanaged Barren Land & Rock	Managed River-Water (W)	203	2019
Unmanaged Other Land	Managed River-Water (W)	68	2015
Unmanaged Barren Land & Rock	Managed River-Water (W)	5	2015
Unmanaged Barren Land & Rock	Managed River-Water (W)	228	2010
Unmanaged Other Land	Managed River-Water (W)	61	2010
Unmanaged Barren Land & Rock	Managed River-Water (W)	386	2005
Unmanaged Other Land	Managed River-Water (W)	17	2005
Unmanaged Other Land	Unmanaged Other Land	3,397	NA
Unmanaged River-Water	Managed Other Land (O)	13	2022
Unmanaged Barren Land & Rock	Managed Other Land (O)	9	2022
Unmanaged River-Water	Managed Other Land (O)	53	2015
Unmanaged River-Water	Managed Other Land (O)	1	2010
Unmanaged River-Water	Managed Other Land (O)	2	2005

Table 87: Land Converted to Other Land between 2005-2022

Initial Land Use	Land Type in Reporting Year	Area (ha)	Year of Conversion
Upland Crop (UC)	Managed Barren & Rock (BR)	32	2022
Rice Paddy/Other Agriculture (RP/OA)	Managed Barren & Rock (BR)	2	2022
Scrub (SR)	Managed Barren & Rock (BR)	1	2022
Mixed Deciduous (MD)	Managed Barren & Rock (BR)	1	2022
Scrub (SR)	Managed Barren & Rock (BR)	66	2015
Scrub (SR)	Managed Barren & Rock (BR)	3	2010
Mixed Deciduous (MD)	Managed River-Water (W)	4,358	2022
Regenerating Vegetation (RV)	Managed River-Water (W)	1,485	2022
Evergreen (EG)	Managed River-Water (W)	1,189	2022
Upland Crop (UC)	Managed River-Water (W)	898	2022
Dry Dipterocarp (DD)	Managed River-Water (W)	450	2022
Rice Paddy/Other Agriculture (RP/OA)	Managed River-Water (W)	191	2022
Plantation Forest (P)	Managed River-Water (W)	15	2022
Savannah (SA)	Managed River-Water (W)	8	2022
Bamboo (B)	Managed River-Water (W)	1	2022
Agricultural Plantation (AP)	Managed River-Water (W)	1	2022
Mixed Deciduous (MD)	Managed River-Water (W)	10,090	2019
Regenerating Vegetation (RV)	Managed River-Water (W)	7,348	2019
Evergreen (EG)	Managed River-Water (W)	4,624	2019
Rice Paddy/Other Agriculture (RP/OA)	Managed River-Water (W)	2,635	2019
Mixed Coniferous and Broadleaved (MCB)	Managed River-Water (W)	523	2019
Dry Dipterocarp (DD)	Managed River-Water (W)	463	2019
Grassland (G)	Managed River-Water (W)	201	2019
Upland Crop (UC)	Managed River-Water (W)	171	2019
Plantation Forest (P)	Managed River-Water (W)	147	2019
Unspecified Wetland	Managed River-Water (W)	142	2019
Savannah (SA)	Managed River-Water (W)	122	2019
Bamboo (B)	Managed River-Water (W)	121	2019
Urban Area (U)	Managed River-Water (W)	89	2019
Agricultural Plantation (AP)	Managed River-Water (W)	31	2019
Scrub (SR)	Managed River-Water (W)	2	2019
Regenerating Vegetation (RV)	Managed River-Water (W)	6,567	2015
Mixed Deciduous (MD)	Managed River-Water (W)	2,748	2015
Rice Paddy/Other Agriculture (RP/OA)	Managed River-Water (W)	1,063	2015

Agricultural Plantation (AP)	Managed River-Water (W)	168	2015
Upland Crop (UC)	Managed River-Water (W)	109	2015
Dry Dipterocarp (DD)	Managed River-Water (W)	83	2015
Evergreen (EG)	Managed River-Water (W)	36	2015
Urban Area (U)	Managed River-Water (W)	19	2015
Unspecified Wetland	Managed River-Water (W)	10	2015
Savannah (SA)	Managed River-Water (W)	6	2015
Grassland (G)	Managed River-Water (W)	5	2015
Mixed Coniferous and Broadleaved (MCB)	Managed River-Water (W)	22,935	2010
Regenerating Vegetation (RV)	Managed River-Water (W)	19,579	2010
Mixed Deciduous (MD)	Managed River-Water (W)	7,693	2010
Grassland (G)	Managed River-Water (W)	5,863	2010
Rice Paddy/Other Agriculture (RP/OA)	Managed River-Water (W)	3,187	2010
Evergreen (EG)	Managed River-Water (W)	1,066	2010
Upland Crop (UC)	Managed River-Water (W)	203	2010
Dry Dipterocarp (DD)	Managed River-Water (W)	178	2010
Unspecified Wetland	Managed River-Water (W)	57	2010
Scrub (SR)	Managed River-Water (W)	17	2010
Plantation Forest (P)	Managed River-Water (W)	1	2010
Agricultural Plantation (AP)	Managed River-Water (W)	1	2010
Regenerating Vegetation (RV)	Managed River-Water (W)	1,134	2005
Coniferous Forest (CF)	Managed River-Water (W)	923	2005
Mixed Deciduous (MD)	Managed River-Water (W)	308	2005
Rice Paddy/Other Agriculture (RP/OA)	Managed River-Water (W)	299	2005
Upland Crop (UC)	Managed River-Water (W)	205	2005
Evergreen (EG)	Managed River-Water (W)	125	2005
Dry Dipterocarp (DD)	Managed River-Water (W)	78	2005
Mixed Coniferous and Broadleaved (MCB)	Managed River-Water (W)	30	2005
Grassland (G)	Managed River-Water (W)	11	2005
Scrub (SR)	Managed River-Water (W)	7	2005
Savannah (SA)	Managed River-Water (W)	2	2005
Unspecified Wetland	Managed River-Water (W)	2	2005
Regenerating Vegetation (RV)	Managed Other Land (O)	1,109	2022
Upland Crop (UC)	Managed Other Land (O)	936	2022
Mixed Deciduous (MD)	Managed Other Land (O)	882	2022
Rice Paddy/Other Agriculture (RP/OA)	Managed Other Land (O)	370	2022
Evergreen (EG)	Managed Other Land (O)	187	2022
Dry Dipterocarp (DD)	Managed Other Land (O)	157	2022
Urban Area (U)	Managed Other Land (O)	20	2022
Bamboo (B)	Managed Other Land (O)	14	2022
Plantation Forest (P)	Managed Other Land (O)	7	2022
Agricultural Plantation (AP)	Managed Other Land (O)	6	2022
Mixed Coniferous and Broadleaved (MCB)	Managed Other Land (O)	1	2022
Mixed Deciduous (MD)	Managed Other Land (O)	1,205	2019
Regenerating Vegetation (RV)	Managed Other Land (O)	1,048	2019
Evergreen (EG)	Managed Other Land (O)	387	2019
Rice Paddy/Other Agriculture (RP/OA)	Managed Other Land (O)	265	2019
Upland Crop (UC)	Managed Other Land (O)	127	2019
Dry Dipterocarp (DD)	Managed Other Land (O)	95	2019
Grassland (G)	Managed Other Land (O)	32	2019
Savannah (SA)	Managed Other Land (O)	19	2019
Plantation Forest (P)	Managed Other Land (O)	16	2019
Agricultural Plantation (AP)	Managed Other Land (O)	12	2019

Coniferous Forest(CF)	Managed Other Land (O)	6	2019
Mixed Coniferous and Broadleaved (MCB)	Managed Other Land (O)	1	2019
Urban Area (U)	Managed Other Land (O)	1	2019
Mixed Deciduous (MD)	Managed Other Land (O)	3,968	2015
Regenerating Vegetation (RV)	Managed Other Land (O)	3,059	2015
Rice Paddy/Other Agriculture (RP/OA)	Managed Other Land (O)	1,050	2015
Dry Dipterocarp (DD)	Managed Other Land (O)	841	2015
Evergreen (EG)	Managed Other Land (O)	411	2015
Upland Crop (UC)	Managed Other Land (O)	333	2015
Grassland (G)	Managed Other Land (O)	73	2015
Urban Area (U)	Managed Other Land (O)	73	2015
Bamboo (B)	Managed Other Land (O)	70	2015
Coniferous Forest(CF)	Managed Other Land (O)	37	2015
Savannah (SA)	Managed Other Land (O)	31	2015
Mixed Coniferous and Broadleaved (MCB)	Managed Other Land (O)	24	2015
Plantation Forest (P)	Managed Other Land (O)	23	2015
Agricultural Plantation (AP)	Managed Other Land (O)	11	2015
Scrub (SR)	Managed Other Land (O)	1	2015
Regenerating Vegetation (RV)	Managed Other Land (O)	1,929	2010
Rice Paddy/Other Agriculture (RP/OA)	Managed Other Land (O)	1,486	2010
Dry Dipterocarp (DD)	Managed Other Land (O)	443	2010
Mixed Coniferous and Broadleaved (MCB)	Managed Other Land (O)	293	2010
Mixed Deciduous (MD)	Managed Other Land (O)	262	2010
Grassland (G)	Managed Other Land (O)	152	2010
Evergreen (EG)	Managed Other Land (O)	54	2010
Urban Area (U)	Managed Other Land (O)	53	2010
Upland Crop (UC)	Managed Other Land (O)	40	2010
Scrub (SR)	Managed Other Land (O)	17	2010
Savannah (SA)	Managed Other Land (O)	9	2010
Plantation Forest (P)	Managed Other Land (O)	2	2010
Regenerating Vegetation (RV)	Managed Other Land (O)	351	2005
Mixed Deciduous (MD)	Managed Other Land (O)	103	2005
Rice Paddy/Other Agriculture (RP/OA)	Managed Other Land (O)	28	2005
Dry Dipterocarp (DD)	Managed Other Land (O)	18	2005
Grassland (G)	Managed Other Land (O)	12	2005
Upland Crop (UC)	Managed Other Land (O)	11	2005
Mixed Coniferous and Broadleaved (MCB)	Managed Other Land (O)	6	2005
Savannah (SA)	Managed Other Land (O)	3	2005

6.3.9. Harvested Wood Products (HWP)

The Harvest Wood Product comprise all wood material (including bark), branches and leaves that are considered organic matter in the land use category (DOM). HWP includes a carbon reservoir[50]. The time carbon is held in product will vary depending on the product and site. Based on the 2006 IPCC Guidelines, provides guidance on when a country may report HWP contribution as zero and not necessarily a detailed estimated.

a). Methodology

The Tier 1 method is used under the **production approach** to estimate changes in carbon stocks in harvested wood products (HWP). This approach assigns emissions and removals to the country where the wood was harvested. It uses default parameters and data provided by the

[50] Article 1 of the UNFCCC defines reservoirs as follows: "Reservoir" means a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored.

2006 IPCC Guidelines for consistent and straightforward reporting. The following assumptions and parameters are applied:

- **First-order decay**: Carbon in HWP is assumed to decline at a constant rate, with decay rates determined by product-specific half-lives;
- **Zero contribution from SWDS**: By default, carbon stock changes in solid waste disposal sites (SWDS) are set to zero, assuming that annual carbon releases equal annual additions to SWDS (The assumption makes reporting consistent with guidance in the 2019 Refinement as well as with the UNFCCC Common Reporting Tables;
- **Default data and parameters**: IPCC Tier 1 defaults are applied for activity data, conversion factors, and decay rates.

This method employs the **First-Order Decay (FOD)** function to model the gradual release of carbon from HWPs over their lifespans. Calculations adhere to Equation 12.1 in the 2006 IPCC Guidelines, Chapter 12, Page 12.10 leveraging default half-lives, decay constants, and carbon conversion factors specified for each HWP pool.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

- Annual harvest: Total volume of wood removed from harvest sites, encompassing industrial roundwood and fuelwood;
- Production, imports, and exports of HWP: Covering sawn wood, wood panels, and paper products;

Conversion of these data into carbon content uses default factors listed in 2006 IPCC Guidelines, Table 12.4, Chapter 12, Page 12.19.

Table 88: Variation 2A- Production of Solid Wood and Paper Products from Wood Harvested

Item	Unit	Quantity of Product		
		Year		
		2020	2021	2022
Fuelwood Production	m3	5695051	5658081	5621880
Fuelwood Import	m3	49	4	4
Fuelwood Export	m3	1451	1451	1451
Sawnwood Production	m3	235000	355000	505000
Sawnwood Import	m3	1529	154	12
Sawnwood Export	m3	157765	260214	109414
Wood-Based Panels Production	m3	51000	51000	51000
Wood-Based Panels Import	m3	13912	15411	5574
Wood-Based Panels Export	m3	1205	8103	8392
Paper & Paperboard Production	Metric-t	0	740000	805000
Paper & Paperboard Import	Metric-t	72322	43371	10195
Paper & Paperboard Export	Metric-t	608	735765	802464
Wood Pulp & Recycled Paper Import	Metric-t	38369	49308	135785
Wood Pulp & Recycled Paper Export	Metric-t	318731	292658	339242
Industrial Roundwood Production	m3	1432000	1432000	1432000
Industrial Roundwood Import	m3	0	11	379
Industrial Roundwood Export	m3	60000	2008127	92490

Other Industrial Roundwood Production	m3	132000	132000	132000
Other Industrial Roundwood Import	m3	0	0	0
Other Industrial Roundwood Export	m3	0	0	0
Chips and particles Import	m3	765042	210132	210132
Chips and particles Export	m3	1771	1771	1771
Wood Charcoal Import	Metric-t	2808	25	21
Wood Charcoal Export	Metric-t	42408	68860	181622
Wood Residue Import	m3	92	76	29
Wood Residue Export	m3	495	1221	1221

QA experts advised that the 'Harvested Wood Products' (HWP) estimates require improved accuracy and consistency, specifically by extending the activity data time series to 1900, in line with the 2006 IPCC Guidelines (Volume 4, Chapter 12). The inventory team acknowledges the significant problem posed by the current short HWP time series, which could result in an overestimation of CO2 removals. While this limitation cannot be resolved for the current BTR1 submission due to timeline pressures, the team has prioritized extending the HWP activity data time series to 1900, following the IPCC guidance, for the upcoming inventory.

d). Emission Factors and Parameters

Tier 1 method, 2006 IPCC Guidelines, Chapter 12, Table 12.2, Page 12.17 is used. The detail is presented as follows:

Default half-lives:

- Solid wood products: 30 years
- Paper products: 2 years

Decay rate k (k = ln (2)/ half-life):

- Solid wood products: 0.023
- Paper products: 0.

CHAPTER VII. WASTE SECTOR

7.1. Overview of Waste Sector

The GHG in the WASTE sector encompass CO_2, CH_4, and N_2O. Those emission were estimated from different sources: Solid Waste Disposal (4.A), Biological Treatment of Solid Waste (4.B), Incineration and Open Burning of Waste (4.C), and Wastewater Treatment and Discharge (4.D).

The total emission in the WASTE sector is 1,448.49 ($GgCO_2eq$), in which the largest emission from CH_4 with the amount of 1,403.99 ($GgCO_2eq$) while the second largest source are from N_2O with the amount of 44.32 ($GgCO_2eq$) and the least emission source are from CO_2 with the amount of 0.17($GgCO_2eq$). The detail of the GHG emission in the WASTE sector for 2022 are presented in (Table 89).

Table 89: GHG Emission of Waste Sector for 2022

Categories	Global Warming Potential Values (AR5) Emission ($GgCO_2eq$)			
	CO_2	CH_4	N_2O	Total
4 - Waste	0.17	1,403.99	44.32	1,448.49
4.A - Solid Waste Disposal	-	423.31	-	423.31
4.A.1 - Managed Waste Disposal Sites	-	NE	-	-
4.A.2 - Unmanaged Waste Disposal Sites	-	410.21	-	410.21
4.A.3 - Uncategorized Waste Disposal Sites	-	13.10	-	13.10
4.B - Biological Treatment of Solid Waste	-	-	-	-
Composting	-	NE	NE	-
Anaerobic digestion at biogas facilities	-	NE	NE	-
Other	-	NE	NE	-
4.C - Incineration and Open Burning of Waste	0.17	-	-	0.17
4.C.1 - Waste Incineration	0.17	-	-	0.17
4.C.2 - Open Burning of Waste	NA	NE	NE	-
4.D - Wastewater Treatment and Discharge	-	980.68	44.32	1,025.01
4.D.1 - Domestic Wastewater Treatment and Discharge	-	267.96	44.32	312.29
4.D.2 - Industrial Wastewater Treatment and Discharge	-	712.72	IE	712.72
4.E - Other (please specify)	NE	NE	NE	-

Table 90: Methodologies used in the Energy Sector

Categories	CO_2		CH_4		N_2O	
	Methods	EF	Methods	EF	Methods	EF
4.A.2 - Unmanaged Waste Disposal Sites	D	T1	D	T1	D	T1
4.A.3 - Uncategorized Waste Disposal Sites	D	T1	D	T1	D	T1
4.C.1 - Waste Incineration	D	T1	D	T1	D	T1
4.D.1 - Domestic Wastewater Treatment and Discharge	D	T1	D	T1	D	T1
4.D.2 - Industrial Wastewater Treatment and Discharge	D	T1	D	T1	D	T1

Note: D: IPCC default value, T1: Tier 1 approach

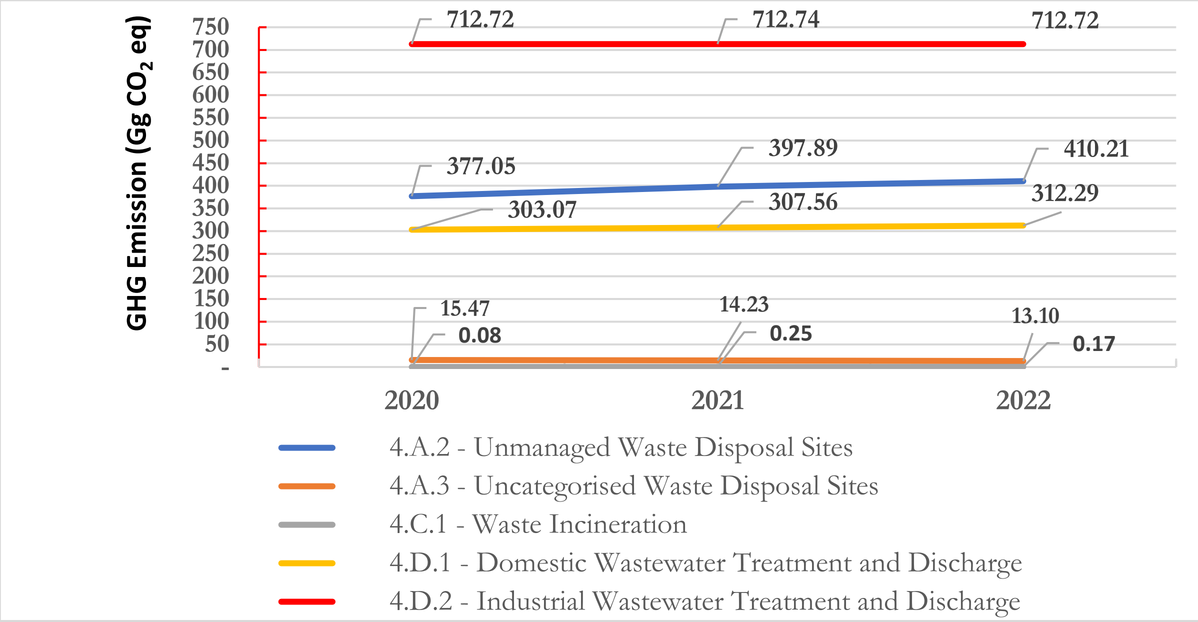


Figure 16: GHG Emission from Five Sub-categories of the Waste Sector, 2020 – 2022

7.1.1. Key Categories of Waste Sector

Table 91. Key Categories of Waste Sector (Including LULUCF)

No	A Code	B Category	C GHGs	AP1-L 2022	AP1-T 2020-2022
#14	4.D	Wastewater Treatment and Discharge	CH_4		
#19	4.A	Solid Waste Disposal	CH_4		
#30	4.D	Wastewater Treatment and Discharge	N_2O		
#51	4.C	Incineration and Open Burning of Waste	CO_2		

Table 92. Key Categories of Waste Sector (Excluding LULUCF)

No	A Code	B Category	C GHGs	AP1-L	AP1-T
#9	4.D	Wastewater Treatment and Discharge	CH_4	#9	#9
#13	4.A	Solid Waste Disposal	CH_4		
#23	4.D	Wastewater Treatment and Discharge	N_2O		
#42	4.C	Incineration and Open Burning of Waste	CO_2		

Note1: Ap1-L: Approach 1-Level Assessment, Ap1-T: Approach 1-Trend Assessment
Note2: Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

7.2. Description of Emission Sources

7.2.1. Solid Waste Disposal (4.A)

a) Methodology

The start year of the parameter for estimating of GHGs emission in Lao PDR has taken since 1960. Two types of Solid Waste Disposal in Lao PDR were applied included Uncategorized SWDS and Unmanaged SWDS shallow. The start year of Uncategorized SWDS was from 1960 – 1997 and an Unmanaged SWDS shallow was from 1998 – 2022.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c) Activity Data (AD)

The AD to estimate the GHG emission comprises the population statistic across the country, waste generation (Ton/year), waste generation per person (ton/person/year), waste composition, degradable organic carbon (DOC fraction of wet weight), degradable organic carbon which decomposes in SWDS (DOCf fraction), and Methane generation rate constants (k). The detail of the AD was described as below.

Population: The historical data of the populations from 1960 – 2022 was applied, in which the statistical data from 1960 – 1976 was used Work Bank's data[51] and from 1977-2022 was used the statistical data from Lao Statistical Information Service (LAOSIS)[52]. The detail was presented in (Figure 17)

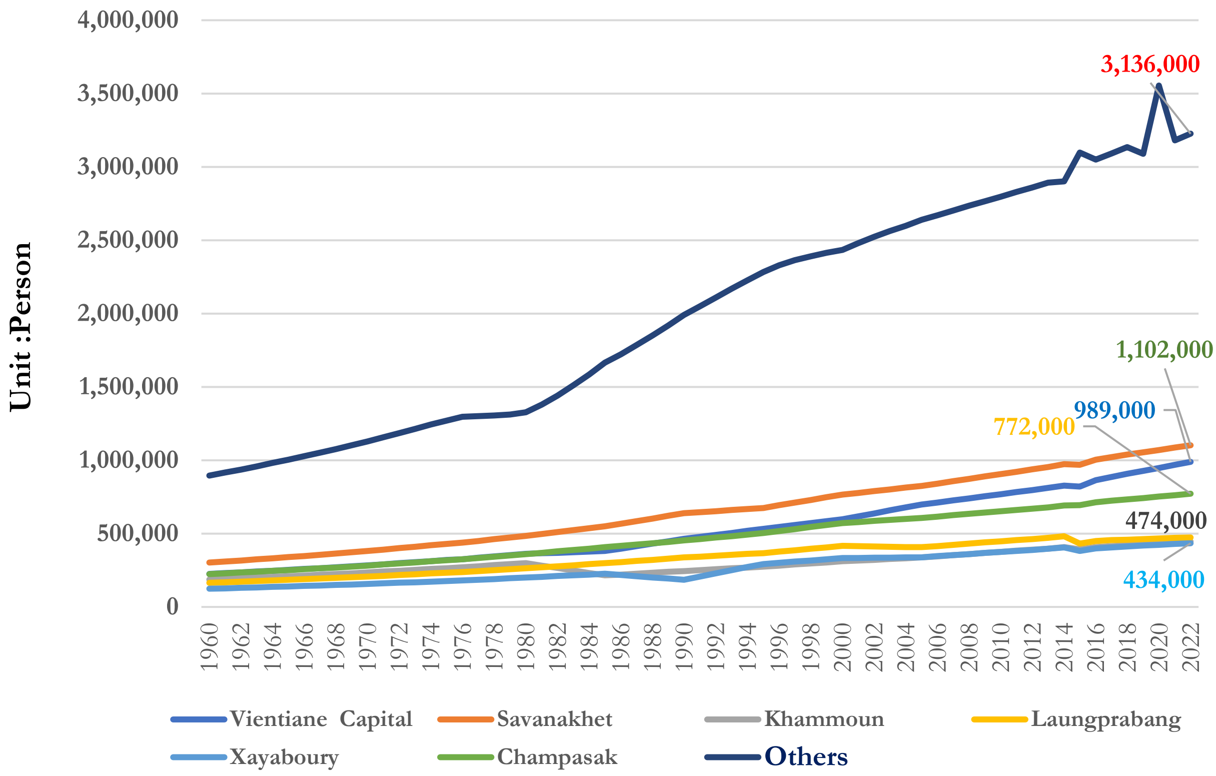


Figure 17: Lao Population's Statistic from 1960 – 2022 (Unit: person)

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[51] World Bank (2024). Population, Total – Lao PDR: https://data.worldbank.org/indicator/SP.POP.TOTL?locations=LA

[52] LAOSIS (2024). Population by province: https://laosis.lsb.gov.la/tblInfo/TblInfoList.do;jsessionid=XHvyQStSI-29K1- BKKagbCRE5mv3rWPDHMBQtyZJ.laosis-web

Waste Generation (Ton/year)

The waste generation from 1960 – 2022 of the six major provinces: Vientiane Capital, Savannakhet, khammaune, Luanprabang, Xayaboury, Champasak, and Others was estimated as follows:

- The waste generation ton per year from 2000 – 2015 was obtained from the World Bank report on Supporting Lao PDR to improve solid and plastic waste management [53].
- The waste generation ton per year before 1999 and from 2016 was estimated by multiplying waste generation per capita by population.

Table 93: The Waste Generation (Ton/Year) from 1960 - 2022

WASTE GENERATION (TON/YEAR) FROM 1960 – 2022								
YEAR	Vientiane Capital	Savanakhet	Khammoaun	Laungprabang	Xayaboury	Champasak	Others	Total waste generation
1960	53,427	71,798	44,259	39,014	29,506	53,111	212,458	503,572
1970	67,341	90,496	55,785	49,173	37,190	66,942	267,786	634,713
1980	85,753	115,067	70,938	62,634	47,450	85,410	315,087	782,339
1990	110,084	151,603	58,126	79,954	43,891	107,475	472,472	1,023,605
2000	141,876	181,734	73,785	98,696	79,005	135,707	577,671	1,288,474
2005	165,676	195,820	79,990	96,605	80,464	144,076	626,618	1,389,250
2010	193,608	112,791	94,412	94,664	228,100	164,403	704,043	1,592,021
2015	214,905	113,080	99,731	102,610	253,907	181,661	810,781	1,776,675
2020	360,000	177,342	160,633	164,810	406,329	285,949	1,190,886	2,745,949
2021	367,975	178,861	162,911	167,089	412,405	289,367	1,207,975	2,786,582
2022	375,570	180,000	164,810	169,367	418,481	293,165	1,225,063	2,826,456

Waste generation per capita (Ton/person/year)

The data from the World Bank report [54] was applied to estimate the waste generation (Ton/person/year) from 1960 - 2022. (Table 94) is shown that the waste generation per capita (Ton/person/year) from 1960 – 2000 was assumed to remain the same with the value of 0.24 (Ton/person/year) while other year from 2000 onward was steady increase.

Table 94: Waste generation (Ton/Person/Year) from 1960-2022

Waste generation per capita (Ton/Person/Year) from 1960 - 2022							
Year	Vientiane Capital	Savanakhet	Khammoun	Laungprabang	Xayaboury	Champasak	Others
1960	0.24	0.24	0.24	0.24	0.24	0.24	0.24
1970	0.24	0.24	0.24	0.24	0.24	0.24	0.24
1980	0.24	0.24	0.24	0.24	0.24	0.24	0.24
1990	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2000	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2005	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2010	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2015	0.26	0.26	0.26	0.26	0.26	0.26	0.26
2020	0.38	0.38	0.38	0.38	0.38	0.38	0.38
2021	0.38	0.38	0.38	0.38	0.38	0.38	0.38
2022	0.38	0.38	0.38	0.38	0.38	0.38	0.38

[53] World Bank, 2021. Supporting Lao PDR to Improve Solid and Plastic Waste Management, Table 2, Page 13.

[54] World Bank, 2021. Supporting Lao PDR to Improve Solid and Plastic Waste Management, Table 2, Page 13.

Waste Composition

The waste composition at the SWDS in Lao PDR includes food waste, garden and park waste, plastic, paper and cardboard, textiles, glass, and other waste. The emission estimation was calculated based on the waste composition at the landfill in Vientiane (the Global Green Growth Institute 2021) [55], as the historical data percentage was unavailable for other major provinces. The detail is presented in (Table 95).

Table 95: Solid Waste Composition from 1960 - 2022

Composition	Percentage (%) From 1960 -2022
Food waste	37
Garden and Park Waste	19
Plastic	27
Paper and Cardboard	6
Textiles	3
Glass	2
Other Waste	6
Total	100

Table 96: DOC, DOCf and Methane Generation Rate Constant (K)

Waste Category	Waste Type/Industry Type	Degradable Organic Carbon	Degradable Organic Carbon Decomposes in SWDS	Methane Generation Rate Constant
		DOC (Fraction of wet weight)	DOCf (Fraction)	K
Municipal Waste	Food waste	0.15	0.5	0.4
	Garden and park	0.2	0.5	0.17
	Wood	0.43	0.5	0.035
	Disposable nappies	0.24	0.5	0.07
	Paper and cardboard	0.4	0.5	0.07
	Textile	0.24	0.5	0.07

d). Fraction

- The fraction of waste disposed at SWDS was only estimated, based on SWDS at KM-32 in Vientiane Capital, as There were no data available on waste disposed at SWDS in other major cities [56];
- The fraction of waste disposed at SWDS was calculated by the total amount of waste disposed (Ton/Year) at SWDS KM-32 divided by waste generation (Ton/Year);
- As the waste disposed data at SWDS KM-32 were only available from 2010-2022, the fraction of waste disposed from 1960-2009 was assumed to be the average amount from 2010 to 2014. The detail is presented in (Table 97).

[55] GGGI (2021). Sustainable Solid Waste Management, Strategy and Action Plan 2021-2030, Chapter 1, Figure 2, page 14.

[56] GGGI (2021). Sustainable Solid Waste Management, Strategy and Action Plan 2021-2030, Chapter 1, Table 05, page 16

Table 97: The Fraction of Waste Disposed at SWDS KM-32

Fraction of Waste Disposed at SWDS KM-32			
Year	Waste Generation (Ton/Year)	Waste Disposed (Ton/Year)	Fraction of Waste Disposed at SWDS (%)
1960-2009	N/A	N/A	40%
2010	193,608	67,525	35
2011	197,867	72,270	37
2012	202,127	86,140	43
2013	206,386	90,520	44
2014	210,646	99,645	47
2015	214,905	103,660	48
2016	243,924	101,470	42
2017	272,943	113,880	42
2018	301,962	127,020	42
2019	330,981	147,825	45
2020	360,000	143,810	40
2021	367,975	141,620	38
2022	375,570	158,410	42

7.2.1.1. Unmanaged Waste Disposal Sites (4.A.2)

a). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

b). Activity Data (AD)

The AD to estimate CH_4 from Unmanaged SWDS includes amount of waste deposited from food waste, garden and park, paper and cardboard, and textile. The detail of data needed from 1998 - 2022 was included in 4.A

c). Emission Factor (EF)

The EFs applied the default value of IPCC guideline 2006 to estimate CH_4 emissions from the SWDS, including the Methane correction factor (MCF) of Unmanaged SWDS - shallow. The detail is shown in (Table 98).

Table 98: MCF for Unmanaged SWDS from 1998-2022

	Methane Correction Factor (MCF) from 1998-2022	
Type of SWDS	MCF value	Source
Unmanaged-Shallow (< 5 m Waste)	0.4	2006 IPCC Guideline, Table 3.1, page 3.14, Volume 5, Chapter 3

d). Emission Result

The methane emissions from Unmanaged SWDS for 2022 are presented in (Table 99)

Table 99: Methane Emission from Unmanaged Waste Disposal for 2022

Categories	Global Warming Potential Values (AR5) Emission ($GgCO_2eq$)						
	CO_2	CH_4	N_2O	CO	NMVOCs	SO_2	Total
4 - Waste							
4.A - Solid Waste Disposal	-						
4.A.1 - Managed Waste Disposal Sites	-	-	-				-
4.A.2 - Unmanaged Waste Disposal Sites	-	539.83	-				539.83

7.2.1.2. Uncategorized Waste Disposal Sites (4.A.3)

a). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

b). Activity Data

The AD to estimate CH_4 from Uncategorized SWDS includes the amount of waste deposited from food waste, the gardens and parks, paper and cardboard, and textiles. The detail of data needed from 1960 - 1997 was included in 4.A.

c). Emission Factor

The EFs applied the default value of IPCC guideline 2006 to estimate CH_4 emissions from the Uncategorized SWDS, including the Methane correction factor (MCF) of Uncategorized SWDS - shallow and deep. The detail is shown in (Table 100)

Table 100: MCF for Uncategorized SWDS from 1960 – 1997

	Methane correction factor (MCF) from 1960 - 1997	
Type of SWDS	**MCF value**	**Source**
Uncategorized SWDS	0.6	IPCC 2006 Guideline, Table 3.1, page 3.14, Volume 5, Chapter 3

d). Result Emission

The methane emissions from Uncategorized SWDS for 2022 are presented in (Table 101)

Table 101: Methane emission from Uncategorized SWDS for 2022

Categories	Global Warming Potential Values (AR5) Emission ($GgCO_2eq$)						
	CO_2	CH_4	N_2O	CO	NMVOCs	SO_2	Total
4 - Waste							
4.A - Solid Waste Disposal	-						
4.A.1 - Managed Waste Disposal Sites	-						
4.A.2 - Unmanaged Waste Disposal Sites	-						
4.A.3 - Uncategorized Waste Disposal Sites	-	15.73	-				15.73

7.2.2. Incineration and Open Burning of Waste (4.C)

7.2.2.1. Waste Incineration (4.C.1)

a). Methodology

- Tier 1 approach has applied to estimate the emission of waste incineration;
- There was only CO_2 emission found during the clinical waste combusted;
- The equation to estimate the CO_2 emission during the clinical waste combusted based on IPCC Guideline 2006, Equation 5.1, Page 5.7, Chapter 5, Volume 5.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.
Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

- Based on the Vientiane Urban Development and Administration Authority (VUDAA) reported that there were only clinical wastes at Vientiane Capital were combusted in the incinerators from 2018 – 2022;
- The AD to estimate the CO_2 emission includes total amount of clinical wastes incinerated (Ton/year) in the incinerator.

Table 102: Amount of Clinical Waste Combusted in the Incinerator at Vientiane Capital [57]

Year	Amount of Clinical Waste (Kg-wet/day)	Number of Days in Year	Amount of Clinical Waste (Ton/Year)
2018	383	365	0.14
2019	374	365	0.14
2020	375	366	0.14
2021	1,194	365	0.44
2022	816	365	0.30
2023	466	365	0.17

d). Emission Factors

The EF to estimate the CO_2 emission from clinical waste combusted in the incinerator included: dry matter content, fraction of carbon in dry matter, fraction of fossil carbon in total carbon, and oxidation factor. The detail is presented in (Table 103).

Table 103: EF to Estimate the CO_2 Emission from Clinical Waste for 2022

EF to estimate the CO_2 Emission from Clinical Waste for 2022 [58] [59]					
Emission	Dry Matter Content (%)	Fraction of Carbon in Dry Matter (%)	Fraction of Fossil Carbon in Total Carbon (FCFi) (%)	Oxidation Factor - OF (Fraction) (%)	
CO_2	0.65	0.6	0.4	1	

[57] VUDAA (2024). Waste Data Collection on Clinical Waste Report, Page 7, Vientiane Capital
[58] The Dry Matter Content in percent was obtained from Table 2.6, Page 2.16 (2006 IPCC Guideline, Chapter 2, Volume 5)
[59] The fraction of Carbon in Dry Matter, Fraction of Fossil Carbon, and Oxidation Factor were obtained from Table 5.2, page 5.18 (2006 IPCC Guideline, Chapter 5, Volume 5)

e). Emission Result

The CO_2 emission from clinical waste is combusted in the incinerator. The detail is presented in (Table 104)

Table 104: CO_2 Emission from Clinical Waste Combusted in the Incinerator for 2022

Categories	Global Warming Potential Values (AR5) Emission (GgCO2eq)						
	CO_2	CH_4	N_2O	CO	NMVOCs	SO_2	Total
4.C - Incineration and Open Burning of Waste	0.17	-	-				0.17
4.C.1 - Waste Incineration	0.17	-	-				0.17
4.C.2 - Open Burning of Waste	-	-	-				-

7.2.2.2. Open Burning of Waste (4.C.1)

As the Lao PDR had no has the proper data on the amount of waste at open-burned, it is advised to consider to include in the next BTR2.

7.2.3. Wastewater Treatment and Discharge (4.D)

Wastewater treatment and discharge is the main source of methane (CH_4) and nitrogen oxide (N20) emissions, while carbon dioxide (CO_2) from wastewater is not taken into account due to its biogenic origin and is not included in national total emissions. The wastewater originates from a diverse domestic, commercial, and industrial source and is treated on-site. It may be treated on-site (uncollected) and severed to a centralized plant (collected). Domestic wastewater is household water use, while industrial wastewater is from industrial practice only (IPCC Guideline 2006, Chapter 6, Volume 5, page 6.5).

7.2.3.1. Domestic Wastewater Treatment and Discharge (4.D.1)

a**). Methodology**

- Tier 1 approach has applied to estimate the emission of Domestic Wastewater;
- The Equation to estimate CH_4 emissions form domestic wastewater was calculated based on IPCC Guideline 2006, Equation 6.1, Page 6.11, Chapter 6, Volume 5.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

The AD for estimating CH_4 emissions f domestic wastewater included population statistic, $BOD5_5$ in inventory year**,** (g/person/day), Correction factor for industrial BOD discharge in sewers, Days per year, Total organics in Wastewater in inventory year (TOW) (kg BOD/Year), and Protein consumption per capital (kg/person/year) . The detail was shown as below.

Population Statistic: The total population statistic in the country for 2020, 2021, and 2022 are 7,231,000, 7,338,000, and 7,443,000 [60] respectively;

[60] LAOSIS (2024). Population by province: https://laosis.lsb.gov.la/tblInfo/TblInfoList.do;jsessionid=XHvyQStSI-29K1- BKKagbCRE5mv3rWPDHMBQtyZJ.laosis-web

BOD_5 in Inventory Year, g/Person/Day: As the Lao PDR did not have country specific BOD_5, the country has used BOD default value 40 (IPCC Guideline 2006, Chapter 6, Volume 5, Table 6.4, Page 6.14).

Correction Factor for Additional Industrial BOD Discharged into Sewers: The correction factor for additional industrial BOD discharged into sewers for uncollected the default is 1 (IPCC Guideline 2006, Chapter 6, Volume 5, Equation 6.3, Page 6.14).

Total Organic in Wastewater in Inventory Year (TOW), Kg BOD/year: The TOW was calculated by IPCC Guideline 2006, Chapter 6, Volume 5, Equation 6.3, Page 6.13. The detail is presented in (Table 105).

Table 105: Total Organic in Wastewater in Inventory Year (TOW) for 2020, 2021, and 2022

	Estimation	Unit	2020	2021	2022
population	A	person	7,231,000	7,338,000	7,443,000
BOD5	B	g/person/day	40	40	40
Correction factor for additional industrial BOD discharged into sewers	C	-	1	1	1
Conversion from grams BOD to Kg BOD	D	-	0.001	0.001	0.001
Days per year	E	Days/year	366	365	365
TOW	E=A*B*C*D*E	KgBOD/year	105,861,840	107,134,800	108,667,800

Degree of Utilization: The degree of utilization was calculated by sewage from domestic households, number of populations, decentralized wastewater treatment. The detail is shown in (Table 106).

Table 106: Decentralized Wastewater Treatment in Lao PDR from 2009-2017 [61]

Decentralized Wastewater Treatment installed in Laos							
No	**Location**	**Type of Technology**	**Commercial Name**	**Treatment Capacity (m^3/day) _ (A)**	**No of Users_ (B)**	**Operation Year**	**Province**
1	Dormitory Resident, FE, NUOL	Anaerobic Treatment	CBS	10	125	2009	Vientiane Capital
2	Thongkhankham Village, Unit 11,12 & 13	Anaerobic Treatment	CBS	11.2	146	2010	Vientiane Capital
3	Khualoung Primary School	Anaerobic Treatment	SBS	7	116	2010	Vientiane Capital
4	Student Dormitory, Northern Agriculture and Forest College	Anaerobic Treatment	SME	15	208	2011	Luang Prabang Province
5	Operation Camp of THPC	Anaerobic Treatment	SME	70	700	2011	Khammuan Province
6	Expansion Camp of THXP	Anaerobic Treatment	SME	30	300	2011	Khammuan Province

[61] Deevanhxay, P (2022). A Baseline Survey on Current Situation and Performance of Domestic Wastewater Treatment System in Lao PDR, Faculty of Natural Science, National University of Laos, Page 22.

7	Khoualoung Temple/School & Village	Anaerobic Treatment	CBS	26	455	2012	Vientiane Capital
8	Hin Heup District	Anaerobic Treatment	CBS	3	66	2013	Vientiane Province
9	Nam Papa State Enterprise Attapeu	Anaerobic Treatment	CBS	14	163	2014	Attapeu Province
10	Nam Papa State Enterprise Attapeu	Anaerobic Treatment	CBS	14	235	2014	Attapeu Province
11	National Academy for Politics and Public Administration	Anaerobic Treatment	RESam	160	1600	2014	Vientiane Capital
12	Navieng Village	Anaerobic Treatment	CBS	14	161	2015	Houanphan Province
13	Health and Science College	Anaerobic Treatment	RESam	10	500	2015	Luanphabang Province
14	Xe Pian-Xe Namnoy Hydropower Plant	Anaerobic Treatment	RESam	8	150	2015	Attapeu Province
15	Lao Disable Women Development Centre	Anaerobic Treatment	RESam	6.4	80	2015	Vientiane Capital
16	GIZ in Laos	Anaerobic Treatment	RESam	1.5	50	2015	Vientiane Capital
17	World Bank	Anaerobic Treatment	RESam	10.2	-	2015	Vientiane Capital
18	Hospital in Xekong Province	Anaerobic Treatment	HoSan	35	50	2016	Xekong Province
19	Pakhoatai Primary School	Anaerobic Treatment	SBS-Lite	1	220	2016	Bokeo Province
20	Night Market in Luangphabang	Anaerobic Treatment	ReSan	5	-	2017	Luangphabang Province
21	Wattay International Airport	Anaerobic & Aerobic Treatment	Johkasou		-	-	Vientiane Capital
22	Wattay Domestic Airport	Anaerobic & Aerobic Treatment	Johkasou		-	-	Vientiane Capital
23	Sethathirath Hospital	Anaerobic & Aerobic Treatment	Johkasou		-	-	Vientiane Capital
24	**Total**			**451.3**	**5,325**		
25	**Decentralized Wastewater Treatment Total (A)/Total (B) = 0.08**						

Table 107: The Degree of Utilization of the Domestic Wastewater Treatment

Efi,j		Unit	2020	2021	2022	Source

Degree of utilization (Ti,j)	Centralized, aerobic treatment plant (well managed)	%	0.60%	0.60%	0.60%	
	Centralized, aerobic treatment plant (not well managed)		0.60%	0.60%	0.60%	
	Septic system	%	11.50 %	11.50 %	11.50 %	
	Untreated system (Sea, river and lake discharge)	%	87.20 %	87.20 %	87.20 %	
		%	100.00%	100.00%	100.00%	
MCF (Methane Correction Factor)	Centralized, aerobic treatment plant (well managed)	---	0	0	0	2006 IPCC GL, Table 6.3
	Centralized, aerobic treatment plant (not well managed)		0.3	0.3	0.3	
	Septic system	---	0.5	0.5	0.5	
	Untreated system (Sea, river and lake discharge)	---	0.1	0.1	0.1	
	Total		0.14678	0.1468	0.1468	
B0		kg CH_4/kg-BOD	0.6	0.6	0.6	2006 IPCC GL
Efi,j	Centralized, aerobic treatment plant (well managed)	kg CH_4/kg-BOD	0.08806	0.08806	0.08806	
E		kt CH_4	9.32	9.43	9.57	

d). Emission Factor

The EF applied to estimate CH_4 and N_2O emissions from the domestic wastewater treatment includes as below:

- Maximum CH_4 producing capacity, kg CH_4/kg BOD = 0.6 (IPCC Guideline 2006, Chapter 6, Volume 5, Table 6.2, Page 6.12);
- $F_{IND\text{-}COM}$ = 1.25 (IPCC Guideline 2006, Chapter 6, Volume 5, Table 6.11, Page 6.26);
- EF_{PLANTS} = Emission factor, (g N_2O/person/year) is 3.2 (IPCC Guideline 2006, Chapter 6, Volume 5, Table 6.11, Page 6.26);
- Emission Factor (EF plant) = 0.0032 (KgN_2O/person/year);
- Fraction of nitrogen in protein (Fnpr)=0.16 (kg N/kg Protein);
- Fraction of non-consumption protein (Fnon-con) =1.1;
- Nitrogen removed with sludge (Nsludge)=0 (Kg);
- Protein consumption per capital per year = 13 Kg;
- Emission factor (KgN_2O – N/kg N) = 0.005

e). Emission Result

The methane emission from domestic wastewater treatment for 2022 are presented in (Table 108)

Table 108: The Methane Emission from Domestic Wastewater Treatment for 2022

Categories	Global Warming Potential Values (AR5) Emission ($GgCO_2eq$)						
	CO_2	CH_4	N_2O	CO	NMVOCs	SO_2	Total
4.D - Wastewater Treatment and Discharge	-						
4.D.1 - Domestic Wastewater Treatment and Discharge	-	267.96	95.47				363.43
4.D.2 - Industrial Wastewater Treatment and Discharge	-						

7.2.3.2. Industrial Wastewater Treatment and Discharge (4.D.2)

Wastewater from industries can either be treated on-site or released into domestic sewer systems. The emissions must be included with the emissions from residential waste if it is discharged into the domestic sewer system. The estimation of CH_4 emissions from the on-site treatment of industrial wastewater is covered in this section. CH_4 can only be produced by treating industrial wastewater with a high carbon input, whether intentionally or accidentally, in an anaerobic environment. COD, which is employed here, is a common metric for expressing organic content in industrial (2006 IPCC Guideline, Chapter 6, Volume 6, Page 6.18).

a). Methodology

- Tier 1 approach has applied to estimate the emission of Industry Wastewater;
- The Equation to estimate CH_4 emissions from Industrial wastewater was calculated based on IPCC Guideline 2006, Equation 6.4, Page 6.20, Chapter 6, Volume 5.

b). Description of any flexibility applied

Flexibility for time series, which starts from the year 2020 to 2022, as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

Flexibility for Uncertainty assessment, where the report only presents a qualitative discussion of uncertainty for key categories as described in Section 1.6. A summary of any flexibility applied is provided throughout the report.

c). Activity Data

The AD for estimating CH_4 emissions from industrial wastewater included total industrial product (Ton/year), Wastewater generated (m3/ton), Chemical Oxygen Demand (COD) (Kg/COD/m3). The detail is presented in (Table 109) and (Table 1).

Table 109: Total Industrial Product from 2020-2022 [62]

Industry type	Unit	2020	2021	2022
Alcohol Refining	ton/year	22,045	22,045	22,045
Beer & Malt	ton/year	131,598	131,598	131,598
Dairy Products	ton/year	19,494	19,494	19,494
Meat & Poultry	ton/year	400,992	400,992	400,992
Organic Chemicals	ton/year	421,645	421,645	421,645
Plastics & Resins	ton/year	346,598	346,598	346,598
Pulp & Paper (combined)	ton/year	58,226	58,226	58,226

[62] MOIC (2021). Development plan on manufacturing and handicraft sectors, Ministry of Industry and Commerce, Laos, Annex 1, page 60

Total industrial product for industrial sector	Soap & Detergents	ton/year	23,955	23,955	23,955
	Starch Production	ton/year	858,417	858,417	858,417
	Sugar Refining	ton/year	22,558	22,558	22,558
	Vegetable Oils	ton/year	60,189	60,189	60,189
	Vegetables, Fruits & Juices	ton/year	600,816	600,816	600,816
	Wine & Vinegar	ton/year	42,085	42,085	42,085
Note: As the industrial production data was only available for 2020, this assumed that the industrial production data for 2021 and 2022 were remain the same value in 2020					

Table 110: Wastewater Generated (m3/ton)

	Industry type	Unit	2020	2021	2022	Source
Wastewater Generation	Alcohol Refining	ton/year	24	24	24	IPCC Guideline 2006, Volume 5, Chapter 6, Table 6.9, Page 6.22
	Beer & Malt	m3/ton	6.3	6.3	6.3	
	Dairy Products	m3/ton	7.0	7.0	7.0	
	Meat & Poultry	m3/ton	13.0	13.0	13.0	
	Organic Chemicals	m3/ton	67.0	67.0	67.0	
	Plastics & Resins	m3/ton	0.6	0.6	0.6	
	Pulp & Paper (combined)	m3/ton	162.0	162.0	162.0	
	Soap & Detergents	m3/ton	3.0	3.0	3.0	IPCC Guideline 2006, Volume 5, Chapter 6, Table 6.9, Page 6.22, medium value of Range for W
	Starch Production	m3/ton	9.0	9.0	9.0	
	Sugar Refining	m3/ton	11.0	11.0	11.0	IPCC Guideline 2006, Volume 5, Chapter 6, Table 6.9, Page 6.22, medium value of Range for W
	Vegetable Oils	m3/ton	3.1	3.1	3.1	IPCC Guideline 2006, Volume 5, Chapter 6, Table 6.9, Page 6.22
	Vegetables, Fruits & Juices	m3/ton	20.0	20.0	20.0	
	Wine & Vinegar	m3/ton	23.0	23.0	23.0	

Table 111: COD Value in Wastewater of Each Type of Industry Sector

	Industry type	Unit	2020	2021	2022	Source
COD Value in Wastewater of Each Type of Industry Sector	Alcohol Refining	kg/m3	11	11	11	IPCC Guideline 2006, Volume 5, Chapter 6, Table 6.9, Page 6.22
	Beer & Malt	kg/m3	2.9	2.9	2.9	
	Dairy Products	kg/m3	2.7	2.7	2.7	
	Meat & Poultry	kg/m3	4.1	4.1	4.1	
	Organic Chemicals	kg/m3	3.0	3.0	3.0	
	Plastics & Resins	kg/m3	3.7	3.7	3.7	
	Pulp & Paper (combined)	kg/m3	9.0	9.0	9.0	
	Soap & Detergents	kg/m3	0.9	0.9	0.9	IPCC Guideline 2006, Volume 5, Chapter 6, Table 6.9, Page 6.22, medium value of Range for W
	Starch Production	kg/m3	10.0	10.0	10.0	IPCC Guideline 2006, Volume 5, Chapter 6, Table 6.9, Page 6.22
	Sugar Refining	kg/m3	3.2	3.2	3.2	
	Vegetable Oils	kg/m3	0.9	0.9	0.9	IPCC Guideline 2006, Volume 5, Chapter 6, Table 6.9, Page 6.22,

						medium value of Range for W
	Vegetables, Fruits & Juices	kg/m3	5.0	5.0	5.0	IPCC Guideline 2006, Volume 5, Chapter 6, Table 6.9, Page 6.22
	Wine & Vinegar	kg/m3	1.5	1.5	1.5	

d). Emission Factor

- Maximum CH_4 producing capacity (BO), applied the default value of 0.25 kg CH_4/kg COD (IPCC Guideline 2006, Chapter 6, Volume 5, Table 6.2, Page 6.12);

e). Result Emission

The methane emission result from industrial wastewater treatment for 2022 are presented in (Table 112)

Table 112: Methane Emission Result from Industrial Wastewater Treatment for 2022

Categories	Global Warming Potential Values (AR5) Emission ($GgCO_2eq$)			
	CO_2	CH_4	N_2O	Total
4.D - Wastewater Treatment and Discharge				
4.D.1 - Domestic Wastewater Treatment and Discharge				
4.D.2 - Industrial Wastewater Treatment and Discharge	-	712.72	-	712.72
4.E - Other (please specify)	-	-	-	-

CHAPTER VIII. RECALCULATION AND IMPROVMENTS

8.1. Recalculation

Based on the MPGs and the 2006 IPPC Guidelines, each party shall report recalculations for the starting year and all subsequent years of the inventory time series, altogether with explanations and justification, implication for emission and removal levels, application of new estimation methods, addition of new categories for emissions and removals, and data updated or refinements, etc. However, as Lao PDR lack of data available, this report will not estimate the recalculation.

8.2. Areas of Improvement and Planned Improvements

Table (113) presented the areas of improvement and planned improvements for the next BTR

Table 113: The Areas of improvement and planned improvements

Energy Sector		
Code	**Category**	**Improvement Actions**
1.A.1. a.2	**Electricity Generation**	1) The actual lignite consumption of the Power Plant for the year 2019-2021 needs to be further discussed and acquired from the Department of Planning and Finance, MEM, and report accordingly. Also, the data on lignite consumption from local sources and the IEA website is quite different. More exploration and confirmation of the differences are needed; 2) There is no local data on biomass consumption from local sources. Thus, IEA data was used to report. For the next BTR, it is advised to further discuss and acquire data from the Department of Planning and Finance, MEM, and report accordingly; 3) Also, the Energy industry is considered a key category according to the approach one method (Including and Excluding LULUCF). According to the 2006 IPCC Guidelines, a higher tier (tiers 2 and 3) should be adopted for all the key categories. However, for this report, paragraph 23 of the MPGs was applied by adopting the tier 1 approach, as data needed for Tier 2 and 3 methods cannot be determined and collected due to a lack of resources. For the future BTR, it is advised to have a further discussion with concerned sectors and adopt the higher tiers.
1.A.2.m	**Non-Specified Industry**	1) There is no local fuel consumption data available for Manufacturing Industries and Construction category. Thus, data on the IEA website were used to report under the non-specified industries for this BTR. For the follow-up report, the actual consumption data by each fuel type and sub-category must be further discussed, collected from the sectors in charge, and reported accordingly; 2) Also, the Manufacturing Industries and Construction category is considered a key category according to the approach one method (Excluding LULUCF). According to the 2006 IPCC Guidelines, a higher tier (tiers 2 and 3) should be adopted for all the key categories. However, for this report, paragraph 23 of the MPGs was applied by adopting the tier 1 approach, as data needed for Tier 2 and 3 methods cannot be determined and collected due to

		a lack of resources. For the future BTR, it is advised to have a further discussion with concerned sectors and adopt the higher tiers.
1.A.3.a. i	**International Aviation**	1) Since no fuel consumption data is available from local sources, data from the ICAO website reported by the Aviation department was used for this BTR. For the next BTR, the fuel consumption data needs to be further discussed, collected from the concerned sector, and reported accordingly. Also, more exploration is needed in terms of the data differences shown on the ICAO and IEA websites.
1.A.3	**Transportation**	1) The data on fuel consumption for the Transportation category (domestic aviation and Road transportation) were not sufficiently collected from each concerned party for a number of reasons. Thus, to be on time to report the 1st BTR, single data available, such as total oil product consumption for Transportation on the IEA website, was used and reported for domestic aviation and road Transportation; 2) Also, the Transportation category is considered a key category according to the approach one method (Including and Excluding LULUCF). According to the 2006 IPCC Guidelines, a higher tier (tiers 2 and 3) should be adopted for all the key categories. However, for this report, paragraph 23 of the MPGs was applied by adopting the tier 1 approach, as data needed for Tier 2 and 3 methods cannot be determined and collected due to a lack of resources. For the future BTR, it is advised to have a further discussion with concerned sectors and adopt the higher tiers.
1.A.3.e. ii	**Off -Road**	1) For the next BTR, annual data on fuel consumption and fuel type for off-road transportation is advised to be further discussed and collected from the relevant sector.
1.A.4.a	**Commercial**	1) No fuel and fuel type consumption data are available for the other sectors (commercial, resident, and agriculture/forestry/fishing/fish farms) category. Thus, the data available on the IEA website was used to report under this category. For the next BTR, the respective data should be further discussed with sectors, collected, and reported accordingly.
1.A.4.b	**Residential**	1) No fuel and fuel type consumption data is available for the other sectors (commercial, resident, and agriculture/forestry/fishing/fish farms) category. Thus, the data available on the IEA website was used to report under this category. For the next BTR, the respective data should be further discussed with sectors, collected, and reported accordingly.
1.A.4.c. ii	**Off Road Vehicle and Other Machinery**	1) No fuel and fuel type consumption data is available for the other sectors (commercial, resident, and agriculture/forestry/fishing/fish farms) category. Thus, the data available on the IEA website was used to report under this category. For the next BTR, the respective data should be further discussed with sectors, collected, and reported accordingly.
1.B.1	**Solid Fuel**	2) For the next BTR, it is advised to further discuss with sectors the quantity of coal produced from underground and surface mines and the overburden area data, as it is claimed by sector that this type of data is confidential and for internal use only

Industry Process and Production Use (IPPU)		
Code	**Category**	**Improvement Actions**
2.A.1	**Cement Production**	1) The Mineral Industry, especially in cement production, is considered a key category according to the approach one method (Including and Excluding LULUCF). According to the 2006 IPCC Guidelines, a higher tier (tiers 2 and 3) should be adopted for all the key categories. However, for this report, paragraph 23 of the MPGs was applied by adopting the tier 1 approach, as data needed for Tier 2 and 3 methods cannot be determined and collected due to a lack of resources. For the future BTR, it is advised to have a further discussion with concerned sectors and adopt the higher tiers.
2.A.2	**Lime Production**	1) For the follow-up report, the data regarding the type of lime production and the quantity of lime produced from 2016-2021 need to be further discussed with concerned sectors and reported accordingly.
2.C.1	**Iron and Steel Production**	3) The steel and Iron-making method is reported to be produced from iron scrap only (Secondary facilities). This means that the steel and iron-making method is EAF, and no coke production exists. However, the data on Iron ore production within the country are available on the LAOSIS website. Thus, whether the iron and steel factories are using iron scrap only or also using iron to proceed is still an issue that needs further exploration and confirmation with the sectors in charge and steel and iron factories for the next BTR.
2.D.1	**Lubricants Use**	1) For the next BTR, the actual Lubricants consumption data needs to be discussed and explored further with the sectors in charge, as this BTR assumed the imported data amount to be the consumption data.
2.D.2	**Paraffin Was Use**	1) For the next BTR, the actual Paraffin wax consumption data needs to be discussed and explored further with the sectors in charge, as this BTR assumed the imported data amount to be the consumption data.
2.F.1.a	**Refrigeration and Stationary Air Condition**	1) For the next BTR, the years of substance introduction, growth rates in new equipment sales, and percentages of gases destroyed at the end of equipment life need to be further discussed and explored with concerned parties.
Agriculture Sector		
Code	**Category**	**Improvement Actions**
3.A	**Livestock Population Characterization**	**Completeness:** • Ensure that all livestock categories are appropriately accounted for and provide a justification for the exclusion of any livestock categories not reported in the inventory. • Study on the status quo of some main animal species such dairy cows and sheep in the country and update their information for the national context. • Identify significant and insignificant animal species to the inventory and apply suitable methods for them (estimation Tiers and notation keys) • Collect disaggregated data on livestock populations and enhanced characterization and feed intake; and apply a method to disaggregate the data appropriately where the source does not distinguish between species. • Collect and update relevant parameters such as number of days alive, subcategory-specific weight of animals. • Gather information on the frequency of activity data collection for each category and, if needed, specify the sources and

		methodologies used to derive or generate the annual activity data.
3.A.1	**Enteric Fermentation**	**Method:** • Prioritize updating the emission factors for enteric fermentation in buffalo and other cattle using the values from Table 10.10 (buffalo, developing countries) and Table 10.11 (other cattle, Asia) of the 2006 IPCC Guidelines.
3.B	**Manure Management**	**Method:** • Consult the Department of Meteorology and Hydrology (DMH) of Lao PDR to obtain accurate, region-specific annual average temperature data and ensure the use of CH_4 EF with appropriate temperature range for the relevant category to align with actual national temperature data. • Collect country-specific data or well-documented expert judgment on the distribution of manure management systems.
3.C.7	**Rice cultivation**	**Completeness:** • Ensure that the harvested area of rice cultivation is used in the estimation of emissions, as required by the 2006 IPCC Guidelines and collect information on multiple rice cropping.
		Method: • Collect detailed information on rice cultivation practices for each rice type, including regional variations in water management, organic amendments, soil type, and cropping patterns to use for refining the selection of scaling factors and improve the representativeness of emission estimates, and provide a transparent explanation of the parameters selected.
		Transparency/documentation: • Gather information on the frequency of activity data collection and the sources and methodologies used to derive or generate the annual activity data, if needed.
3.C.4-5	**Direct and indirect N2O emissions from agricultural soils**	**Completeness** • Gather information on cultivation of organic soils in the country or find supporting information or references (e.g. national soil maps, inventories, or expert assessments), and include estimates if such soils exist.
		Transparency/Documentation • Prioritize updating the data and version of the activity data used for synthetic fertilizer application, including the date of data extraction from FAOSTAT. • Gather information on the frequency of activity data collection for each category and, if needed, specify the sources and methodologies used to derive or generate the annual activity data.
3.C.1.c	**Prescribed burning of savannahs**	**Method:** • Collect and refine all relevant parameters (e.g. biomass density, fraction oxidized, carbon and nitrogen content), while ensuring consistency in the data sources used for activity data and biomass estimates to avoid discrepancies in derived values.
		Transparency/Documentation • Gather information on the frequency of activity data collection for each category and, if needed, specify the sources and methodologies used to derive or generate the annual activity data.
3.C.1.b	**Field burning of agricultural residues**	**Method:** • Enhance the activity data used for estimating emissions from field burning of agricultural residues. Align the estimates of

		crop residues burned with those reported under N_2O emissions from managed soils to avoid double counting. Apply Equation 2.27 from Chapter 2, Volume 4 of the 2006 IPCC Guidelines, using a single, estimate of residue availability consistent with residue estimations in direct N2O emissions from agricultural soils. • Collect national data on the fraction of crop residues that are actually burned in the field and use this information to replace default values where possible.
		Transparency • Gather information on the frequency of activity data collection for each category and, if needed, specify the sources and methodologies used to derive or generate the annual activity data.
3.C.1-2	**CO2 emissions from liming, urea application and other carbon-containing fertilizers**	**Transparency** • Gather information on the frequency of activity data collection for each category and, if needed, specify the sources and methodologies used to derive or generate the annual activity data.
LULUCF Sector		
Code	**Category**	**Improvement Actions**
3.B	Land Representation	**Completeness:** • Apply interpolation and extrapolation methods to available land-use change data of 5–10 years intervals as estimates for the reporting are required on an annual basis. • Ensure the choice of land area value used in the inventory and ensure consistency with other national reports and sources, or clearly explain any deviations. **Method:** • Provide a clear definition and methodological description of how managed and unmanaged lands are identified in the inventory, in line with the 2006 IPCC Guidelines. • Consider applying the managed land proxy to the entire national territory, as this approach is consistent with 2006 IPCC Guidelines and more accurately reflects the national circumstances of Lao PDR. • Introduce appropriate stratification of land areas based on climate, soil type, ecological zones, and management practices, especially when applying default emission factors and carbon stock change parameters. **Transparency:** • Revise the classification of land-use categories where necessary to ensure consistency with the 2006 IPCC Guidelines. • Gather detailed information on identifying land-use conversions, and seek to understand conversions that appear atypical, such as urban areas transitioning to forest or cropland; and update the land-use conversion data to ensure that non-existent changes are not included in the Land Use Change matrixes. • Include in the NIR explicit definitions for all carbon pools used in the estimation of carbon stock changes and emissions/removals, and indicate whether they align with the definitions provided in the 2006 IPCC Guidelines.
3.B.1	Forest Land	**Transparency in forest land** • Enhance all activity data, emission factors, and parameters used in the estimation of emissions and removals for the entire time series, and provide sources and references at the same level of

		disaggregation used in the calculations, along with the rationale for assigning each value to a land-use or forest type. • Gather information on the frequency of activity data collection for each category and, if needed, specify the sources and methodologies used to derive or generate the annual activity data.
3.B.1.a	Forest land remaining forest land	• Ensure a consistent application of the Gain–Loss method by disaggregating biomass loss estimates (e.g., harvest, fuelwood removals) across all forest subcategories where gains are reported. • Consider applying the stock-difference method for estimating CSCs using the existing national information if reliable and internally consistent data to support the Gain–Loss method cannot be collected. • Apply higher-tier methods for significant carbon pools within Forest Land Remaining Forest Land, in accordance with the decision trees provided in the 2006 IPCC Guidelines.
3.B.1.b	Land Converted to Forest Land	• Apply higher-tier methods for significant carbon pools within Land converted to Forest Land, in accordance with the decision trees provided in the 2006 IPCC Guidelines. • Review and revise the biomass growth rate (Gw) values used for Land Converted to Forest Land to reflect the typical growth dynamics of younger forest stands, in accordance with the 2006 IPCC Guidelines.
3.B.2	Cropland	**Method:** • Gather information on organic soils in the country and find supporting information or references (e.g. national soil maps, inventories, or expert assessments), or include estimates if such soils exist. • Ensure that the selected FLU, FMG, and FI factors reflect the actual land-use and management practices in each category. Provide detailed documentation in the NIR on the values and sources of the Relative Stock Change Factors (FLU, FMG, and FI) applied to each cropland subcategory. **Transparency in cropland:** • Provide information on defining these stratification approach used of cropland, and ensure that this information aligns with the emission estimation methods reported and the national circumstances. • Enhance all activity data, emission/removal factors, and other parameters used for each land-use category and carbon pool, clearly specifying the time series values, sources, and methodological references.
3.B.2.a	Cropland Remaining Cropland	• Apply higher-tier methods for the estimation of carbon stock changes in Cropland Remaining Cropland, at a minimum, for significant pools.
3.B.2.b	Land Converted to Cropland	• Apply higher-tier methods for the estimation of carbon stock changes in Land converted to Cropland, at a minimum, for significant pools.
3.B.3	Grassland	**Completeness in grassland:** • Estimate CSCs for areas of grassland converted between subcategories. • Gather information whether management practices have remained unchanged for areas remaining in the same grassland type, and, if so, explicitly apply the Tier 1 assumption of zero CSCs in biomass. **Method:**

		• Collect data for estimates of the Relative Stock Change Factors (FLU, FMG, and FI) applied to grassland categories. **Transparency:** • Provide information on defining these stratification approach used for grassland, and ensure that this information aligns with the emission estimation methods reported and the national circumstances. • Enhance all activity data, emission/removal factors, and other parameters used for each land-use category and carbon pool, clearly specifying the time series values, sources, and methodological references.
3.B.4	Wetlands	**Method:** • Revise the land-use classification to ensure that unmanaged wetlands are correctly identified and reported under the Wetlands category, in accordance with the 2006 IPCC Guidelines. • Establish and document clear criteria for distinguishing between managed and unmanaged wetlands, including how these criteria are applied in practice. • Verify that areas classified as unmanaged, such as water bodies, are not subject to human intervention or management activities (e.g. irrigation infrastructure, dams), to ensure that only truly unmanaged areas are reported as such. **Transparency in wetlands:** • Provide information on defining these stratification approach used for wetlands, and ensure that this information aligns with the emission estimation methods reported and the national circumstances. • Enhance all activity data, emission/removal factors, and other parameters used for each land-use category and carbon pool, clearly specifying the time series values, sources, and methodological references.
3.B.5	Settlements	**Transparency in settlements:** • Provide information on defining these stratification approach used for settlements, and ensure that this information aligns with the emission estimation methods reported and the national circumstances. • Enhance all activity data, emission/removal factors, and other parameters used for each land-use category and carbon pool, clearly specifying the time series values, sources, and methodological references. • Revise the estimation of SOC changes for Land Converted to Settlements to align with the 2006 IPCC Guidelines.
3.B.6	Other Land	**Method:** • Apply higher-tier methods for the estimation of carbon stock changes in Land converted to Other Land, at a minimum, for significant pools. • Revise the estimation of SOC changes for Land Converted to Other Land to align with the 2006 IPCC Guidelines. **Transparency in other land:** • Enhance all activity data, emission/removal factors, and other parameters used for each land-use category and carbon pool, clearly specifying the time series values, sources, and methodological references.
3.C.4-5	Direct and indirect nitrous oxide (N2O) emissions	**Completeness:** • Clarify in the NIR and in the documentation box of CRT 4(I) where the emissions reported as "Included Elsewhere" are

	from nitrogen (N) inputs to managed soils	allocated and provide a justification for the allocation approach used.
	Direct and indirect nitrous oxide (N2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils	**Method:** • Allocate the emissions to the appropriate category, ensuring that only N_2O emissions from management changes in cropland remaining cropland and grassland remaining grassland for agriculture purpose are reported table 3.D, while emissions resulting from carbon stock losses in mineral soils due to any other change are reported under the LULUCF sector in CRT 4(III). **Transparency:** • Include in the NIR a dedicated section presenting all activity data, emission factors, and parameters used for the entire time series, along with their corresponding sources and references. • Gather information on the frequency of activity data collection for each category and, if needed, specify the sources and methodologies used to derive or generate the annual activity data.
3.C.1	Biomass Burning	**Method:** • Revise the allocation of wildfires to ensure that all types of forest are considered in the estimations. For example, by disaggregating the area of wildfires based on the percentage of the total area of forest represented by each forest type. **Transparency:** • Gather information on the frequency of activity data collection and the source of the data. • Include complete methodological information for forest land, including data sources, parameters used, and explanations for relevant interannual changes.
3.D.1	Harvested Wood Products	**Method:** • Prioritize extending the activity data time series back to 1900 following the guidance provided in the 2006 IPCC Guidelines, volume 4, chapter 12, in order to improve the accuracy and consistency of the estimates. **Transparency:** • Ensure that all activity data, emission factors and parameters used throughout the time series are transparently documented, including their sources. • Clarify the methodology applied for extrapolation of historical data. • Align the parameters reported in the NID with those used in the IPCC software
Waste Sector		
Code	**Category**	**Improvement Actions**
4.A	Solid Waste Disposal	1) **Population:** The population from 1950-1960 should be estimated; 2) **Waste generation per capita**: - The waste generation per capita in rural areas should be investigated; - The waste generation from tourist sector should be investigated 3) **Fraction of waste disposed at SWDS(Urban)**: The flow of the rest of MSW (about 60%) must be checked in next BTR; 4) **Waste composition:** - The additional investigation in urban areas should be done to understand the ratio of wood in urban areas;

		- The additional investigation in rural areas is encouraged to be done to understand the waste composition in rural areas 5). A diagram showing all waste streams and distribution between management practice should be included in next BTR; 6). The pathways and disposal practices of uncollected municipal solid waste should be conducted surveys for the next BTR
		5) **Activity data** - The activity data of sludge should be collected
4.B.1	Compositing	The activity data of fertilizer facility should be collected in next BTR
4.C.1	Open Burning of Waste	1). The amount of waste-open-burned across the country should be estimated in next BTR; 2). Methane (CH_4) and nitrous oxide (N_2O) emissions from the incineration of clinical waste should be estimated and reported in the next BTR
4.D	Wastewater Treatment and Discharge	1) The Wastewater Treatment and Discharge, is considered a key category according to the approach one method (Excluding LULUCF). According to the 2006 IPCC Guidelines, a higher tier (tiers 2 and 3) should be adopted for all the key categories. However, for this report, paragraph 23 of the MPGs was applied by adopting the tier 1 approach, as data needed for Tier 2 and 3 methods cannot be determined and collected due to a lack of resources. For the future BTR, it is advised to have a further discussion with concerned sectors and adopt the higher tiers.

ANNEX

ANNEX 1. KEY CATEGORIES

The Key Categories is included in the 1.4. Briefs Description of Key Categories, Page 7.

ANNEX 2. ASSESSMENT OF UNCERTAINTY

The country has applied the flexibility Para. 29 of decision 18/CMA.1 to the Assessment of Uncertainty due to limited technical capacity, data collection infrastructure, and time constraints for developing the NIR. The party plans to improve these areas in the future NIR. Below is the qualitative discussion of uncertainty for key category.

Table 114: Assessment of Uncertainty

Categories Sectors	Qualitative discussion
Energy- 1.A.1 Energy Industries - Solid Fuels	Uncertainty in the energy industries' CO2 emissions results from filling the lignite consumption data gap by applying the interpolation formula, especially for 2019-2021, due to the unavailability of local data sources and reliance on global default emission factors (Tier 1).
Energy- 1.A.3.b Road Transportation - Liquid Fuels	Uncertainty in the road transportation's CO2 emissions stems from the unavailability of disaggregated activity data (fuel consumption) by vehicle type for road transport- as required for reporting in the CRT tables (i.e., disaggregation into cars, light-duty trucks, heavy-duty vehicles and buses, and motorcycles)—emissions from road transport are reported in aggregate under the 'Car' sub-category and reliance on global default emission factors (Tier 1).
Energy-1. A.2-Manufacturing Industries and Construction - Solid Fuels	Uncertainty in the Manufacturing Industries and Construction's CO_2 emissions stems from the unavailability of disaggregated activity data, (fuel consumption) by sub-categories as required for reporting (i.e., disaggregation into Iron and Steel, Chemicals, Pulp, Paper and Print, Food Processing, Beverages and Tobacco, Non-Metallic Minerals, Transport Equipment, Machinery, Mining (excluding fuels) and Quarrying, Wood and wood products, Construction, Textile and Leather, and Non-specified Industry)—emissions from Manufacturing Industries and Construction are reported in aggregate under the ' Non-specified Industry ' sub-category, and reliance on global default emission factors (Tier 1).
Industrial Processes and Product Use - 2.A.1 Cement production	Uncertainty in Cement production's CO2 emissions was caused by the tier 1 assumption of an overall clinker fraction of 75%. Since clinker activity data (AD) significantly influences CO2 emissions from cement production, applying a single overall clinker fraction across the entire time series introduces substantial uncertainty and accuracy issues in the estimated emissions.
Agriculture – 3.A.1 Enteric Fermentation	Using the Tier 1 method for methane (CH4) emissions from enteric fermentation introduces significant uncertainty, typically ranging from ±30% to ±50%. Adopting higher-tier methodologies

	and gathering more detailed, country-specific data on livestock and feed characteristics can substantially reduce this uncertainty.
Agriculture – 3.C.4 Direct N2O emissions from managed soils	Estimates of direct nitrous oxide (N2O) emissions from managed soils are highly uncertain due to issues with emission factors, natural variability, partitioning fractions, activity data, limited measurement coverage, spatial aggregation, and a lack of specific information on farm practices. Inventories that rely on emission measurements not representative of all national conditions will introduce additional uncertainty. Improving the quality of activity data and utilizing national-specific data are critical for reducing these uncertainties.
Agriculture – 3.C.7 Rice cultivation	Assessing uncertainty in methane (CH4) emissions from rice cultivation is difficult due to the unavailability of key activity data needed for scaling factors, such as information on cultural practices and organic amendments. This often forces reliance on expert judgment to estimate the proportion of farmers using specific practices and to determine the associated uncertainty ranges. For Tier 1 estimates, uncertainty ranges can be based on values provided in the IPCC Guidelines.
Agriculture – 3.A.2 Manure management (CH4)	Significant uncertainties in methane (CH4) emissions from manure management arise when using default Tier 1 emission factors, with an estimated uncertainty range of ±30%. Moving to Tier 2 methodologies can reduce this uncertainty to an estimated ±20%. Specifically for Lao PDR, utilizing country-specific manure management conditions and collecting more detailed data on livestock and feed characteristics will further improve the accuracy of estimates.
Agriculture – 3.A.2 Manure management (N2O)	Uncertainties in default nitrogen (N) excretion rates and N retention values are substantial, both estimated at approximately ±50%. These uncertainties can be significantly reduced by using more accurate in-country statistics on N intake and N retention. Furthermore, obtaining detailed information on country-specific manure management systems and improving measurements of nitrogen losses will also help to lower the uncertainty. There's also a broad uncertainty range for default emission factors in this category, from -50% to +100%. This can be mitigated by accurate and well-designed emission measurements from well-characterized manure types and management systems. These measurements must consider factors such as temperature, moisture, aeration, manure N content, metabolizable carbon, and storage duration.
Agriculture – 3.C.5 Indirect N2O emissions from managed soils	Similar to direct N2O emissions, indirect N2O estimates from managed soils are uncertain due to issues with emission factors, natural variability, partitioning fractions, activity data, limited measurement coverage, spatial aggregation, and a lack of specific information on farm practices. Using emission measurements that are not representative of all conditions within a country will increase inventory uncertainty. Improving the quality of activity

	data and relying on national-level data are key to reducing the uncertainty rate.
LULUCF 3.B.1.a Forest land remaining forest land	Uncertainties in forest land carbon estimates stem from various parameters. Collecting national data for forest carbon factors (including basic wood density, annual increment in managed forests, growing stock, combined natural losses, wood and fuelwood removals, and carbon stock in dead organic matter (DOM) and soils) is essential for conducting high-quality uncertainty assessments.
LULUCF 3.B.2.b Land converted to cropland	Uncertainty here can vary significantly depending on whether global or national average conversion rates and land area estimates are used. Relying on default parameters for carbon stocks in initial and final land conditions also contributes to higher uncertainty. Since "Land Converted to Cropland" is likely a key source category for Lao PDR, significant efforts should be made to reduce its uncertainty.
LULUCF 3.B.1.b Land converted to forest land	The same principles for uncertainty discussed under "Forest Land Remaining Forest Land" apply here. Using specific conversion periods will lead to more accurate estimates. The uncertainty in estimating biomass stocks before and after conversion is often high, but this can be reduced by conducting sample field studies in dominant land-use categories undergoing conversion. While uncertainty for industrial roundwood removal is likely low due to national statistics, fuelwood removal and gathering and biomass loss due to disturbance are likely to have high uncertainty. Sample surveys in different socio-economic and climatic regions can help reduce uncertainty for commercial and traditional methods. Key activity data needed for carbon stock change estimation include converted land area and biomass loss rates during and after initial conversion. Uncertainty for intensive and extensive plantations is likely low, as most countries track afforested and reforested areas. Developing a land-use change matrix for both "Forest Land Remaining Forest Land" and "Land Converted to Forest Land" using remote sensing or other monitoring techniques, ideally combined with ground surveys, can achieve an uncertainty as low as 10-15%.
LULUCF 3.B.6.b Land converted to other land	Uncertainty here primarily arises from using global or national averages for biomass carbon stocks in Forest Land or Other Land uses before conversion, and from coarse estimates of the areas converted. Carbon stock estimations will also carry uncertainties as defined in the relevant sections of the Guidelines.
LULUCF 3.D.1 Harvested wood products	Using Tier 2 methods can significantly improve the accuracy of the five HWP variables. The uncertainty associated with using default product production and trade (activity data) and parameters is detailed in the 2006 IPCC Guidelines, Volume 4, Chapter 12. When national data and parameters are available, uncertainties should be evaluated according to the guidance in Volume 1, Chapter 3.

Wastewater Treatment and Discharge 4. D.1	The uncertainty in the emission estimates for category 4.D.1 (Wastewater Treatment and Discharge) in Lao PDR is driven by the use of IPCC default parameters due to limited availability of national-specific data. The key parameters with high uncertainty include the BOD generation per capita, methane correction factors (MCFs) for different treatment pathways, and emission factors for CH_4 and N_2O emissions, population data, and protein intake per capital

ANNEX 3. QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PLAN

Quality Control (QC) is a technical activity performed by personnel compiling the inventory to check the data integrity, correctness, and completeness; Identifying and addressing errors and omissions; documenting and achieving inventory material; and recording all QC activities. General methods for QC activities include accuracy checks on data acquisition and calculations and using approved standardized procedures for emission and removal calculations, measurements, estimating uncertainness, achieving information, and reporting. QC activities also include technical reviews of categories, activity data, emission factors, and estimation parameters and methods.

Quality Assurance (QA) is a system to be conducted by personnel not directly involved in the inventory development/preparation process, independent third parties. The QA activities will be performed upon the completion of the QC process.

A.3.1. QA/QC Procedures Applied

QC activities in Laos, such as checking data consistency between different sources, the correctness of calculation, and archiving of the documents) at each step, follow the 2006 IPCC Guidelines. In Laos, the QC activities relating to inventory compilation performed by former Ministry of Natural Resource and Environment (MONRE) (including national consultant teams and international expert teams), relevant ministries, and agencies are considered QC activities. External reviews by experts outside the inventory compilation system are considered QA activities.

Table 115 : QA/QC procedures Applied

	Implementing Entity	Main Contents of the Activity
QC (Quality Control)	Former Ministry of Natural Resources and Environment (MoNRE)	• Coordinating QA/QC activities for inventory preparation; • Checking and approving the QA/QC plan; • Checking and approving the inventory improvement plan
	Local consultant Team	• Data collection; • Selection of methods, emission factors, activities and other estimation parameters; • Estimation of emissions or removal; • Documentation and archiving
	International expert teams from Mitsubishi UFJ Research and Consulting Ltd., Japan	• Reviewing whole data collection, data entry process, and preparing GHGs report writing

	Relevant Ministries and Agencies	• Checking data necessary for inventory preparation; • Discussing and assessing estimation methods, EFs
	Project steering community	• Review the inventory

A.3.1.1. QC Activity

General QC Procedures

General QC, including quality checks related to calculations, data processing, and documentation that apply to all inventory source and sink categories according to Table 6.1, Chapter 6: QA/QC and Verification, page 6.9 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

In Laos, sectoral experts under the local consultant team perform as the inventory's compilers for each inventory under the supervision of a sectoral expert from the Japanese government; the National consultant under the supervision of the expert from the Japanese government performs as a National Inventory Compiler (NIC), who integrates the information from the individual SEs and compiles the inventory; and the data providers, who provide the AD and other data used to calculate emissions and removals.

Sectoral Expert (SE)

Local SEs under supervision of international SEs perform mainly the following QC activities.

- Checking for transcription errors in data entry and referencing;
- Checking to ensure that emissions are accurately estimated;
- Checking to see that parameters and emission units are accurately recorded, and that proper conversion factors are used;
- Checking the conformity of databases and/or files;
- Checking the consistency of data from one category to another;
- Checking completeness;
- Checking time series consistency;
- Conducting comparisons with past estimated values;
- Checking that uncertainties in emissions and removals are accurately estimated and calculated;
- Carrying out reviews of internal documentation;
- Checking that the assumptions and criteria for selecting AD and EFs are documented

National Inventory Compiler (NIC)

The NIC under supervision of international NIC mainly following QC actives.

- Confirming that data provided by SEs are imported to the CRT Reporting Tool without omission;
- Confirming that the information needed for the documentation box is properly entered;
- Confirming that the reasons for “NE” and “IE” are correctly entered;
- Confirming that the key category analysis results are correctly outputted;
- Confirming that the reasons for recalculations are provided for all categories;
- Confirming that emissions and removals are correctly aggregated;
- Confirming that data are corrected after the coordination with the relevant ministries and agencies

A.3.1.2. QC Procedures for Each Source and Sink Category

The following category-specific QC activities are performed in Laos:

A.3.1.2.a. QC Through Coordination with the Relevant Ministries and Agencies (External QC)

The quality control for data activity was done through several validation workshops, with each respective ministry in charge of each sector, as separate individual workshops and collective workshops to discuss the consistency of the data from the different data sources, data choices, and data accuracy.

A.3.1.3. QC Activities of the Documentation and Archiving of Inventory Information

Fomer MONRE promptly implements QC activities of the documentation and archiving of inventory information, after the inventory submission to the UNFCCC Secretariat.

Reference

DOLF, 2017: Guideline for strategic target of the livestock and Fishery

DOF, 2018: Lao PDR's Forest Reference Emission Level and Forest Reference Level for REDD+ Results Payment under the UNFCCC, Ministry of Agriculture and Forestry (MAF

DOPC, 2021: Agricultural Statistics Yearbook 2020, Ministry of Agriculture and Forestry

DOPC, 2022: Statistical Yearbook Energy and Mines 2022, Ministry of Energy and Mine

Deevanhxay, P 2022: A Baseline Survey on Current Situation and Performance of Domestic Wastewater Treatment System in Lao PDR, Faculty of Natural Science, National University of Laos, Page 22.

DOF, 2023: Annual Report of Wildfires Across Laos.

DOPC, 2023: Agricultural Statistics Yearbook 2022, Ministry of Agriculture and Forestry

FAO, 2024: Global Forest Resources Assessment – LAO PDR

FAOSTAT, 2024: Crops and livestock products: https://www.fao.org/faostat/en/#data/QCL

FAOSTAT,2024: Detailed trade matrix (fertilizers): https://www.fao.org/faostat/en/#data/RFM

FAOSTAT, 2024: Emissions from Crops: https://www.fao.org/faostat/en/#data/GCE

FAOSTAT, 2024: Emissions from Fires: https://www.fao.org/faostat/en/#data/GI

FAOSTAT, 2024: Fertilizers by Product: https://www.fao.org/faostat/en/#data/RFB

FAOSTAT, 2024: Forestry Production and Trade: https://www.fao.org/faostat/en/#data/FO

GGGI, 2022: Sustainable Solid Waste Management, Strategy and Action Plan 2021-2030

IEA, 2020: Lao Energy Balance tables, Energy Statistics Data

IEA, 2021: Lao Energy Balance tables, Energy Statistics Data

IEA, 2022: Lao Energy Balance tables, Energy Statistics Data

LAO PDR, 2013: Second National Communication to the UNFCCC

LBS, 2015: Statistical Yearbook 2015, Ministry of Planning and Investment (MPI), Laos

LSB, 2019: Statistical Yearbook 2019, Ministry of Planning and Investment, Lao PDR

LSB, 2020: Statistical Yearbook 2020, Ministry of Planning and Investment, Lao PDR

LSB, 2022: Statistical Yearbook 2022, Ministry of Planning and Investment, Lao PDR

LAO PDR, 2023: Implementation Plan for the Nationally Determined Contributions of Lao PDR.

LNFMS, 2024: Forest Change Analysis and Average Carbon Stock: https://nfms.maf.gov.la/

MEM, 2018: Lao PDR Energy Statistics 2018, Ministry of Energy and Mine

MAF, 2021: Law on Forestry (Revised) No.8/National Assembly

MOIC, 2021: Development plan on manufacturing and handicraft sectors, Ministry of Industry and Commerce, Laos, Annex 1, page 60

MEM & ERIA 2020: Energy Demand and Supply of the Lao PDR 2010 – 2018, Ministry of Energy and Mine, Lao PDR

VUDAA, 2024: Waste Data Collection on Clinical Waste Report, Page 7, Vientiane Capital

Vongpaphane, M & Rob, 2020: From Subsistence to Commercial Rice Production in Lao PDR

WBG, 2019: Climate Change Knowledge Portal (CCKP, 2019). Climate Data: Historical https://climateknowledgeportal.worldbank.org/country/lao-pdr/climate-data-historical

WIRS, 2020: Trade Stats, World Integrated Trade Solution

World Bank, 2021: Supporting Lao PDR to Improve Solid and Plastic Waste Management, Table 2, Page 13.

World Bank & ADB, 2021: Climate Risk Country Profile – LAO PDR.

WITS, 2024: Lao PDR Limestone flux; limestone and other calcareous import - export 2020-2022