THAILAND'S FIRST
BIENNIAL TRANSPARENCY REPORT

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UNDP

DEPARTMENT OF CLIMATE CHANGE AND ENVIRONMENT

THE KINGDOM OF THAILAND

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FOREWORD

Thailand is pleased to submit its Biennial Transparency Report (BTR) on its climate change response to the UNFCCC. Thailand's First BTR is prepared under the Enhanced Transparency Framework (ETF), according to the Modalities, Procedures and Guidelines (MPGs) in the decision 18/CMA.1 Annex. According to the guidelines of the MPGs in the Decisions 18/CMA.1 and 5/CMA.3 of the Parties to the Paris Agreement, the member countries of the Paris Agreement shall submit the First Biennial Transparency Reports no later than December 31, 2024.

The GHG inventory was developed according to the methodology described in the 2006 IPCC guidelines, which provides the necessary indicators for consistent, comparable, complete, accurate and transparent inventories. As a developing country, Thailand needs the flexibility of Paragraphs 57-58 of the MPGs in the decision 18/CMA.1 Annex to present a consistent annual time series starting from 2000 as an integral part of its first BTR.

In the First Biennial Transparency Report, the main purposes are to present updated information on the nation's circumstances, gender equality, institutional arrangement, the national GHGs Inventory between 2000 and 2022, achievement of GHG emission reduction under the overall implementation of NDC Action Plan on mitigation measures, together with constraints, gaps, and support needed and received to implement its climate action in adaptation, mitigation, and enabling environment as well as fulfilling its transparency requirement under the Paris Agreement. The revisions focus on the alignment of mitigation measures and 2050 carbon neutrality and 2065 net-zero GHG emissions, just transition, and optimization of socio-economic impacts. In the 2nd updated NDC, Thailand elevated the contribution level to 40%, with 30% from the domestic effort and 10% from international support. This target is challenging for the energy, transport, and agriculture sectors. The challenge also includes raising awareness and participation from all relevant sectors, particularly the private sector, which urgently needs to adapt and enhance its capacity for business competition to keep pace with the rapidly changing global circumstances and trends.

On behalf of the Department of Climate Change and Environment (DCCE), Ministry of Natural Resources and Environment (MONRE), I would like to express my sincere gratitude to the Global Environment Facility (GEF) for the funding and the United Nations Development Programme (UNDP), a coordinating and implementing agency, for its technical support. My appreciation also extends to representatives of Ministries, sub-national government agencies, academic institutions, private sectors, civil societies, non-governmental organizations, and international agencies for their contributions in the preparation of this report.

Thailand, as a developing country, has realized these capacity needs for improvement, and continuously required financial and technical support in enhancing its national capacities to mitigate these gaps, more stringent measures applied under the Paris Agreement's framework, Katowice Climate Package, specified implementation MPGs for the transparency framework, as well as BTR preparation. The climate change issues and their impacts have increased tremendously. The country bears more responsibility to escalate the level of its implementation by encouraging more stakeholders' participation, and intensifying national readiness in tackling the issues. Finally, Thailand will continue to put the utmost effort into prioritizing and implementing our policies to combat climate change and limit the increase of global average temperature under the Paris Agreement according to the country's vision toward net-zero GHG emissions by the second half of this century.

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LIST OF ACRONYMS, ABBREVIATIONS, AND UNITS

AAGR	Annual Average Growth Rate
AEDP 2018	Alternative Energy Development Plan 2018-2037
AD	Activity Data
ADB	Asian Development Bank
AF	Adaptation Fund
Agri - Map	Agricultural Map for Adaptative Management
AIM	Asia-Pacific Integrated Assessment Model
ALCBT	Asia Low Carbon Buildings Transition
AR5	IPCC Fifth Assessment Report
ARDA	Agricultural Research Development Agency (Public Organization)
AWD	Alternate Wetting and Drying
BAAC	Bank for Agriculture and Agriculture Cooperatives
BAU	Business-as Usual
BCG	Bio-Circular-Green Economy
BECCS	Bioenergy with Carbon Capture and Storage
BEVs	Battery Electric Vehicles
BES-Net	Biodiversity and Ecosystem Services Network
BIOFIN	Biodiversity Finance Initiative
BMA	Bangkok Metropolitan Administration
BTR	Biennial Transparency Report
BTR1	First Biennial Transparency Report
CAAT	Civil Aviation Authority of Thailand
CAEP	Climate Action Enhancement Package
CAP	Climate Action Plans
CAPCI	Climate Action Programme for the Chemical Industry
CARP	UNFCCC Centralized Accounting and Reporting Platform
CBD	Convention on Biological Diversity
CBS	Cell Broadcast Service
CBT	Community-Based Tourism
CCE center	Climate Change and Environmental Center
CCMB	Climate Coastal and Marine Biodiversity
CETP	Clean Energy Transitions Programme
CF - Hotels	Carbon Footprint Hotel
CH_4	Methane
CIF	Cooling Innovation Fund
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMA	Conference of the Parties serving as the meeting of the Parties to the Paris Agreement
CRT	Common Reporting Table
CO	Carbon Monoxide
CO_2	Carbon Dioxide

COD	Chemical Oxygen Demand
CRI	Climate Risk Index
CSA	Climate-Smart Agriculture
CSC	Alarm Relay Station
DASTA	Designated Areas for Sustainable Tourism Administration (Public Organization)
DCCE	Department of Climate Change and Environment
DCCT	Decarbonization of Cement and Concrete in Thailand
DDPM	Department of Disaster Prevention and Mitigation
DEDE	Department of Alternative Energy Development and Efficiency
DET	Data Entry Template
DIW	Department of Industrial Works
DLA	Department of Local Administration
DLD	Department of Livestock Development
DMCR	Department of Marine and Coastal Resources
DMF	Department of Mineral Fuels
DMPP	Department of Disaster Prevention and Mitigation
DMR	Department of Mineral Resources
DNP	Department of Natural Parks, Wildlife and Plant Conservation
DOA	Department of Agriculture
DOAE	Department of Agricultural Extension
DOH	Department of Health
DOI	Department of Industrial
DOM	Dead Organic Matter
DOT	Department of Tourism
DPIM	Department of Primary Industries and Mines
DPT	Department of Public Works and Town and Country Planning
DWR	Department of Water Resources
EAF	Electric Arc Furnaces
EbA	Ecosystem-based Adaptation
EEP2018	Energy Efficiency Plan 2018-2037
EERs	Energy Efficiency Resources
EES	Energy Storage SystemsIPS
EF	Emission Factors
EGAT	Electricity Generating Authority of Thailand
ENMAPS	Effectively Managing Networks of Marine Protected Areas in Large Marine Ecosystems
EPAs	Environmentally Protected Areas
EPO	Environmental and Pollution Control offices
EPPO	Energy Policy and Planning Office
EV	Electric Vehicles
EVAC	Satellite Alarm Receivers
EWS	Early Warning System
FCDO	The United Kingdom’s Foreign, Commonwealth and Development Office
FCEVs	Fuel Cell Electric Vehicles

FIO	Forest Industry Organization
FREL	Forest Reference Emission Level
FRL	Forest Reference Level
GBF-EAS	Global Biodiversity Framework Early Action Support
GBP	The Sterling
GCF	Green Climate Fund
GCMs	General Circulation Models
GCoM	Global Covenant of Mayors for Climate and Energy
GDP	Gross Domestic Product
GEF	Global Environment Facility
GGA	Global Goal on Adaptation
GHG	Greenhouse Gas
GIS	Geographic Information Systems
GISTDA	Geo-Informatics and Space Technology Development Agency
GIZ	Deutsche Gesellshaft für Internationale Zusammenarbeit
GPP	Green Public Procurement
GWP	Global Warming Potential
H2Uppp	Hydrogen Ramp - up Programme
HEVs	hybrid electric vehicles
HFCs	Hydrofluorocarbons
HII	Hydro-Informatics Institute (Public Organization)
HNAP	The Health National Adaptation Plan
HPMP	HCFCs Phase Out Management Plan
IFRC	The International Federation of Red Cross and Red Crescent Societies
IMPROVE	Introducing Measures, Pathways and Roadmaps for Optimizing Vehicle Efficiency and Electrification
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IPS	Independent Power Supply
IS	Institutional Strengthening of National Ozone Unit
ITMOs	Internationally Transferred Mitigation Outcomes
IUCN	International Union for Conservation of Nature
JCM	Joint Crediting Mechanism
KCA	Key Category Analysis
ktoe	kiloton of oil equivalent
Lao PDR	Lao People's Democratic Republic
LAOs	Local Administrative Organizations
LDCs	Least Developed Countries
LDD	Land Development Department
LT-LEDS	Long-term Low Greenhouse Gas Emission Development Strategy
LULUCF	Land Use, Land-Use Change, and Forestry
M&E	Monitoring and Evaluation

MDES	Ministry of Digital Economy and Society
MHESI	Ministry of Higher Education, Science, Research, and Innovation
MIND	Ministry of Industry
MIS	Management Information Systems
MNRE	Ministry of Natural Resources and Environment
MOAC	Ministry of Agriculture and Cooperatives
MOE	Ministry of Energy
MOI	Ministry of Interior
MOPH	Ministry of Public Health
MOTS	Ministry of Tourism and Sports
MOU	Memorandum of Understanding
MPAs	Marine Protected Areas
MPGs	Modalities, Procedures and Guidelines
MRTA	Mass Rapid Transit Authority of Thailand
MRV	Measurement Reporting and Verification
MS	Manure Management
MSDHS	Ministry of Social Development and Human Security
MSW	Municipal Solid Waste
N_2O	Nitrous Oxide
NACAG	Nitric Acid Climate Action Group
NAMA	Nationally Appropriate Mitigation Action
NAP	National Adaptation Plan
NbS	Nature-based Solutions
NBSAPs	National Biodiversity Strategies and Action Plans
NBTC	Office of the National Broadcasting and Telecommunication Commission
NC	National Communication
NCB	National Committee on the Conservation and Utilization of Biodiversity
NCCC	National Committee on Climate Change Policy
NCDs	Non-communicable Diseases
NDC	Nationally Determined Contributions
NDPMC	National Disaster Prevention and Mitigation Committee
NGOs	Non-governmental Organizations
NH_3	Nitrogen Trifluoride
NMVOCs	Non-Methane Volatile Organic Compounds
NO_2	Nitrogen Dioxide
No_x	Nitrogen Oxides
NRCT	National Research Council of Thailand
NWCDC	National Water and Climate Data Center
NWRC	National Water Resource Committee
O&M	Operational and Maintenance
O_3	Ozone
OAE	Office of Agricultural Economics

OECD	Organization for Economic Co-operation and Development
OECM	Other Effective Conservation Measures
OIC	Office of Industrial Economics
ONEP	Office of Natural Resources and Environmental Policy and Planning
ONLB	Office of the National Land Policy Board
ONWR	Office of National Water Resources
OPS	Office of the Permanent Secretary
OTP	Office of Transport and Traffic Policy and Planning
PA	Paris Agreement
PCD	Pollution Control Department
PDC	Pacific Disaster Center
PDP 2018 Rev.1	Power Development Plan 2018-2037
PES	Payment for Ecosystem Services
PFCs	Perfluorocarbons
PM10	Particulate Matters 10 microns
PM2.5	Particulate Matters 2.5 microns
POPs	Stockholm Convention on Persistent Organic Pollutants
PRD	The Public Relations Department
PTTEP	PTT Exploration and Production Plc
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RAOT	Rubber Authority of Thailand
RCP	Representative Concentration Pathway
RE	Renewable Energy
RFD	Royal Forest Department
RID	Royal Irrigation Department
RUCaS	Resilient Urban Centres and Surrounds
SAF	Sustainable Aviation Fuel
SCALA	Support Programme on Scaling up Climate Ambition on Land Use and Agriculture
SCP	Sustainable Consumption and Production
SDGs	Sustainable Development Goals
SF_6	Sulphur Hexafluoride
SIDS	Small Island Developing States
SO_2	Sulphur Dioxide
SPAR6C	Supporting Preparedness for Article 6 Cooperation
SRES	Special Report on Emission Scenarios
SRT	State Railway of Thailand
SSNM	site-specific nutrient management
STAR	Sustainable Tourism Acceleration Rating
STGs	Sustainable Tourism Goals
SWDS	Solid Waste Disposal Site
SWOC	Smart Water Operation Center Monitor

TACCC	Transparency, Accuracy, Completeness, Consistency, and Comparability
TAT	Tourism Authority of Thailand
TBA	Thai Banker’s Association
TCMA	Thai Cement Manufacturers Association
tCO_2eq	tons of carbon dioxide equivalent
TDRI	The Thailand Development Research Institute
TGC – EMC	Thai - German Cooperation on Energy Mobility and Climate
TGEIS	Thailand Greenhouse Gas Emission Inventory System
ThaiCI	Thai Climate Initiative
TMD	The Meteorological Department
TRF	Office of the Thailand Research Fund
UK PACT	United Kingdom Partnering for Accelerated Climate Transition
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
Urban Act	Urban Climate Action for low carbon and resilient cities project
USAID	The United States Agency for International Development
USD	United States dollar
WAM	With Additional Measures
WEM	With Measures
WMA	Wastewater Management Authority
WOM	Without Measures

EXECUTIVE SUMMARY

Thailand, as a Non-Annex I Party to the United Nations Framework Convention on Climate Change (UNFCCC), is obligated to submit Biennial Update Reports (BURs) every 2 years. The BURs shall be prepared in accordance with the guidelines contained in decision 2/CP.17. Thailand submitted its first, second, third, and fourth BURs on 29 December 2015, 29 December 2017, 25 December 2020, and 29 December 2022 respectively. In addition, Thailand ratified the Paris Agreement on April 22, 2016. According to the Paris Agreement, all Parties to the Convention and the Paris Agreement are required to submit national inventories of greenhouse gas (GHG) emissions and removals, in accordance with the Modalities, Procedures and Guidelines (MPGs), for the Transparency Framework for Action and Support Referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex). This report, the first BTR, contains updates of national Greenhouse Gas inventories, including a national inventory report and information on tracking progress of the implementation and achievement of Nationally Determined Contributions (NDCs), needs and support received, prepared in accordance with the MPGs. In addition, information on climate change impacts and adaptation is provided in this BTR. Thailand has demonstrated the country's intention to actively implement climate actions and share the results with UNFCCC and the global community. This BTR consists of five chapters as follows:

NATIONAL CIRCUMSTANCES

Thailand's physical context reveals the vulnerability to climate impacts as above-average temperatures tend to rise, precipitation has fluctuated over time, population structure is becoming an "aging society," and its long coastal zone faces coastal erosion and sea-level rise. The country's natural resources exhibit not only abundance and absorptive capacity but also the degrading conditions from climate-induced disasters. Thailand relies largely on commercial energy production and consumption but the share of renewable energy has continued increasing. The COVID-19 pandemic caused a significant economic contraction during 2020-2022. The COVID-19 controlling measures resulted in reduction of energy consumption and production, and economic activities during 2020-2022.

In terms of institutional arrangement for climate change management, Thailand established a National Committee on Climate Change Policy (NCCC). The NCCC serves as a national institute overseeing climate policy development and implementation. The NCCC is composed of eight subcommittees: 1) Subcommittee on Climate Change Policy and Planning Integration, 2) Subcommittee on Climate Change Knowledge and Database, 3) Subcommittee on Climate Change Negotiation and International Cooperation, 4) Subcommittee on Public Relations and Actions for Climate Empowerment 5) Subcommittee on Climate Law, 6) Subcommittee on Thailand Climate Action Conference 7) Subcommittee on the Mobilization of GHG Mitigation with Carbon Sequestration in LULUCF Sector and 8) Subcommittee on the Mobilization of GHG Mitigation with CCUS Technology Implication.

NATIONAL GREENHOUSE GAS INVENTORY

Thailand's GHG inventory was developed and submitted according to Articles 4 and 12 of the UNFCCC and Article 13 of the Paris Agreement. The use of flexibilities for inventory reporting, with respect to the provision in accordance with the MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex), are summarized in Chapter 2.

The estimated emissions in this inventory report were prepared on the basis of the Intergovernmental Panel on Climate Change (IPCC) 2006 IPCC Guidelines for National Greenhouse Gas Inventories, and any subsequent version or refinement of the IPCC guidelines agreed upon by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA). The GHG emissions estimated by Thailand Greenhouse Gas Emission Inventory System (TGEIS) include direct emissions

Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur Hexafluoride (SF_6) and Nitrogen Trifluoride (NF_3).

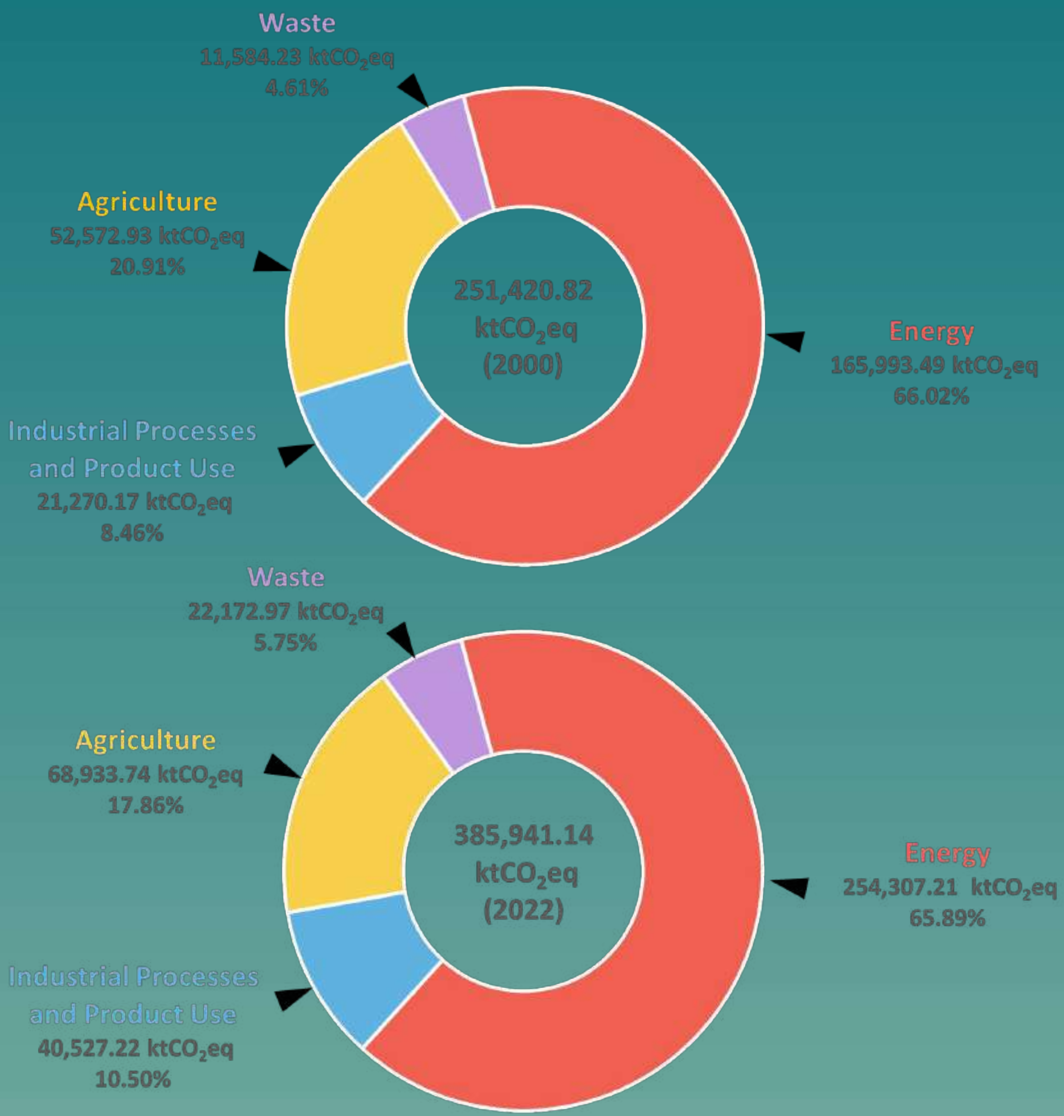


Figure S1: Total GHG emissions by sector (excluding LULUCF) for 2000 and 2022

Total GHG emissions (excluding those from (LULUCF) increased from 251,420.82 $ktCO_2eq$ in 2000 to 385,941.14 $ktCO_2eq$ in 2022, with an average annual increase of 1.97%. The net removal of CO_2 increased from 45,321.86 $ktCO_2eq$ in 2000 to 107,901.43 $ktCO_2eq$ in 2022. Net GHG emissions therefore increased overall from 206,098.92 $ktCO_2eq$ in 2000 to 278,039.71 $ktCO_2eq$ in 2022, with an average annual increase of 1.37%.

Between 2000 and 2022, the main source of GHG emissions was the Energy sector, which saw an increase from 165,993.49 $ktCO_2eq$ in 2000 to 254,307.21 $ktCO_2eq$ in 2022. The proportion of GHG emissions in the energy sector accounted for 66.02% of total emission sources in 2000, decreasing to 65.89% of total emission sources in 2022. In the same period, the share of emissions from the Agriculture sector decreased from 20.91% in 2000 to 17.86% in 2022, the IPPU sector increased from 8.46% in 2000 to 10.50% in 2022, and the shares of emissions from the Waste sector slightly increased from 4.61% in 2000 to 5.75% in 2022.

INFORMATION NECESSARY TO TRACK PROGRESS MADE IN IMPLEMENTING AND ACHIEVING NATIONALLY DETERMINED CONTRIBUTIONS UNDER ARTICLE 4 OF THE PARIS AGREEMENT

The information necessary to track progress made in implementing and achieving Nationally Determined Contributions under Article 4 of the Paris Agreement is provided in Chapter 3, in accordance with the MPGs, for the Transparency Framework for Action and Support Referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex). The information includes Thailand's NDC under Article 4 of the Paris Agreement, including updates, information necessary to track progress made in implementing and achieving its NDC under Article 4 of the Paris Agreement, and information on mitigation policies and measures, actions and plans, related to implementing and achieving a NDC under Article 4 of the Paris Agreement.

INFORMATION ON CLIMATE CHANGE IMPACTS AND ADAPTATION

Thailand is highly vulnerable to climate change, ranked as the 9th most affected country by climate change (2000 – 2019). The country experiences climate change impacts across multiple dimensions, such as flash floods, droughts, storms, landslides, and coastal erosion, especially in mountainous areas in the north and along the coast.

In response, Thailand has made significant progress in integrating climate change adaptation into its national strategies and sectoral plans. Key priorities include enhancing water resource management, improving agricultural resilience, promoting sustainable tourism, addressing public health challenges, strengthening natural resource management, and ensuring the resilience of human settlements and security. The National Adaptation Plan (NAP) serves as the central framework and guiding actions across sectors with principles such as sustainable development, ecosystem-based adaptation, and community participation.

Notable strategies include the 20-Year Water Resources Management Master Plan, the Health National Adaptation Plan (HNAP), the Agriculture Action Plan for Climate Change, the National Biodiversity Action Plans 2023 – 2027, the National Disaster Prevention and Mitigation Plan, and the development of low-carbon tourism routes. Additionally, Thailand addresses loss and damage through comprehensive disaster prevention plans and innovative early warning systems. Localized adaptation initiatives, such as the Thai-Rice NAMA project, coral conservation activities on Koh Mak, and the restoration of the Doi Chiang Dao Biosphere Reserve, highlight effective adaptation measures.

Thailand's monitoring and evaluation (M&E) framework emphasizes adaptation planning, implementation and outcomes. The country is also advancing efforts to develop systems for tracking adaptation outcomes, including the formulation of climate resilience indicators to measure national adaptive capacity over the medium and long term.

Despite these advancements, significant challenges persist. These include insufficient indicators for adaptation actions, limited knowledge, and difficulties in integrating adaptation into long-term plans and ensuring effective stakeholder engagement. Sector-specific adaptation gaps and barriers are identified in Chapter 4.

INFORMATION ON FINANCIAL, TECHNOLOGY DEVELOPMENT AND TRANSFER AND CAPACITY-BUILDING SUPPORT NEEDED AND RECEIVED UNDER ARTICLES 9–11 OF THE PARIS AGREEMENT

The support received from various international partners to facilitate climate actions in Thailand in mitigation, adaptation, and cross-cutting, including other facilities supporting activities under the Paris Agreement are described in Chapter 5, in accordance with the MPGs, for the Transparency Framework for Action and Support Referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex).

Chapter I

NATIONAL CIRCUMSTANCES

THAILAND'S FIRST BIENNIAL TRANSPARENCY REPORT

CHAPTER 1
NATIONAL CIRCUMSTANCES

1.1 PHYSICAL CONTEXT

1.1.1 Geography

The Kingdom of Thailand is situated at the center of the Indochinese Peninsula, within the Southeast Asia region. Thailand is located between latitudes 5° 37' N and 20° 27' N and longitudes 97° 22' E and 105° 37' E encompassing a total area of 513,115 km^2. The borders of Thailand connect with Myanmar and Lao People's Democratic Republic (Lao PDR) to the north, to Lao PDR, Cambodia and the Gulf of Thailand to the east, to Malaysia to the south, and to Myanmar and the Andaman Sea to the west (see Figure 1-1). The coastline of Thailand is 3,151.13 km, divided into the eastern coast (2,039.78 km) and the western coast (1,111.35 km).

From a geographical perspective, Thailand's administrative area is divided into six regions: 1) North, 2) Northeast, 3) Central, 4) East, 5) West and 6) South. Thailand comprises 77 provinces, allocated into three government administration levels: central, provincial and local.

Figure 1-1: Geography of Thailand (Martin, 2024)

1.1.2 Population

In 2022, the registered population in Thailand was approximately 66.1 million, making it the 22nd most populous country in the world. By gender, the population of Thailand consisted of 32.3 million males and 33.8 million females. The country's annual average growth rate (AAGR) was -0.12% (see Figure 1-2).

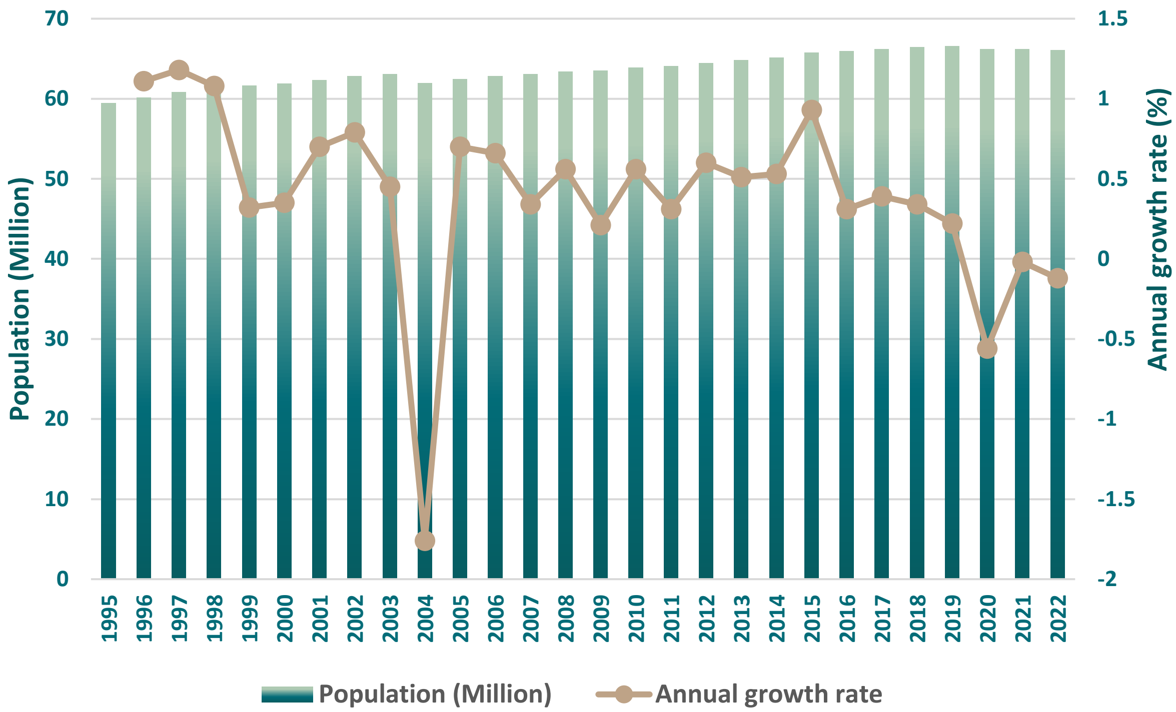


Figure 1-2: Population of Thailand during 1995–2022

Table 1-1 shows the population projection of Thailand for the period of 2020–2040. The population is projected to slightly increase to approximately 67.1 million in 2030, followed by a continuous decline, reaching around 65.4 million by the end of next decade. The population structure is transitioning into an "aging society" due to a persistently low fertility rate since 2020. This trend brings forth two main challenges for Thailand: to 1) support birth of newborns and 2) to formulate national policies that promote social and health services for mothers and children.

Table 1-1: Projection of population in Thailand during 2020 – 2040 ((NESDC, 2013) and (NESDC, 2019))

Population projections	2020	2025	2030	2035	2040
1. Population					
0 – 14 years	11,225,072	10,637,212	9,916,612	9,149,160	8,363,327
15 – 19 years	43,269,391	41,917,127	40,105,230	38,334,858	36,498,965
60 and over	12,040,221	14,534,657	17,118,697	19,102,768	20,510,045
Total	**66,534,684**	**67,088,996**	**67,140,539**	**66,586,786**	**65,372,337**
2. Fertility rates	1.53	1.47	1.41	1.36	1.30
3. Life expectancy at birth (years)					
Male	73.23	74.33	75.27	76.07	76.75
Female	80.35	81.28	82.04	82.66	83.15

1.2 ENERGY SITUATION

1.2.1 Energy consumption

In 2022, Thailand's final energy consumption amounted to 81,948 ktoe (kilotons of oil equivalent), reflecting an increase of 13.6% compared to the previous year. Commercial energy consumption constituted 88.3% of the total final energy consumption while renewable energy accounted for 11.7%. The consumption of petroleum products represented the largest share at 46.7% of the total final energy consumption, followed by electricity, coal and its derivatives, natural gas, renewable energy and traditional renewable energy, which accounted for 21.1%, 10.3%, 9.7%, 7.7% and 4.0%, respectively (see Figure 1-3).

In 2022, the industrial sector was the largest consumer of energy by economic sector, utilizing 32,437 ktoe, which represented 39.6% of overall final energy consumption. This was a 22.0%, increase from the previous year. The transportation sector was the second-highest consumer, with a consumption of 30,927 ktoe, accounting for 37.7% of overall final energy consumption in 2022 (see Figure 1-4).

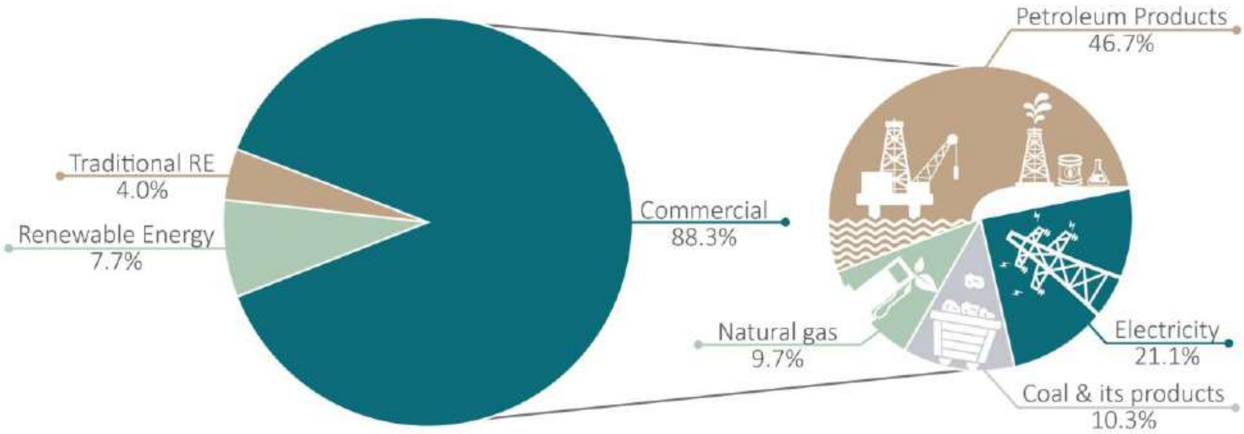


Figure 1-3: Thailand's final energy consumption by fuel type in 2022 (DEDE, 2024)

FINAL ENERGY CONSUMPTION BY ECONOMIC SECTOR	QUANTITY (ktoe)			GROWTH (%)	
	2020	2021	2022	2021	2022
1. Agricultural	2,318	2,234	2,152	-3.6	-3.7
2. Industrial	28,837	26,598	32,437	-7.8	22.0
3. Residential	10,150	9,675	9,726	-4.7	0.5
4. Commercial	6,336	6,194	6,706	-2.2	8.3
5. Transportation	29,699	27,460	30,927	-7.5	12.6
Total	**77,340**	**72,161**	**81,948**	**-6.7**	**13.6**

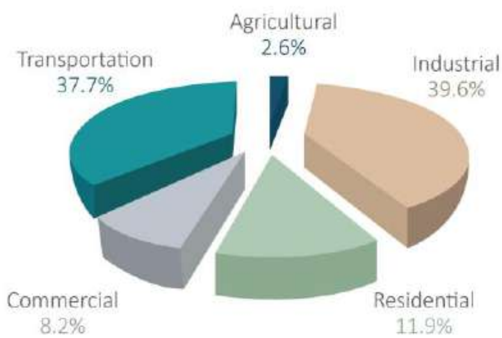


Figure 1-4: Thailand's final energy consumption by economic sector in 2022 (DEDE, 2024)

1.2.2 Energy Production

In 2022, total energy production in Thailand was 57,875 ktoe, a decrease of 7.4% compared to the previous year. It comprised 58.1% commercial energy, 30.1% renewable energy (RE), 7.9% traditional RE, 3.4% biofuel, and 0.1% other sources (see Figure 1-5).

ENERGY PRODUCTION	QUANTITY (ktoe)			GROWTH (%)	
	2020	2021	2022	2021	2022
Total Energy Production	65,821	62,503	57,875	-5.0	-7.4
Commercial Energy	41,871	40,340	33,630	-3.7	-16.6
• Crude oil	5,860	4,923	3,977	-16.0	-19.2
• Lignite	3,282	3,523	3,379	7.3	-4.1
• Natural gas	28,865	28,279	23,394	-2.0	-17.3
• Condensate	3,864	3,615	2,880	-6.4	-20.3
Renewable Energy	16,020	15,248	17,390	-4.8	14.0
Traditional RE	5,179	4,354	4,526	-15.9	4.0
Biofuel	2,343	2,105	1,926	-10.2	-8.5
Other Energy	408	456	403	11.8	-11.6

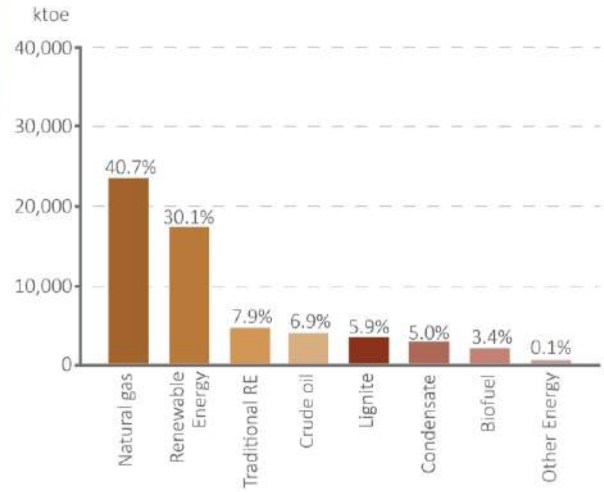


Figure 1-5: Thailand's energy production in 2022 2022 (DEDE, 2024)

1.2.3 Energy imports and exports

In 2022, total energy imports were 81,186 ktoe, reflecting a 3.4% increase from the previous year. Crude oil, natural gas and coal were mainly commercial energy imports. Crude oil accounted for the largest share at 56.1% of total energy import, followed by natural gas at 17.7% and coal at 16.5% (see Figure 1-6).

IMPORT OF ENERGY	QUANTITY (ktoe)			GROWTH (%)	
	2020	2021	2022	2021	2022
Total Energy Production	77,199	78,527	81,186	1.7	3.4
Commercial Energy	77,155	78,485	81,186	1.7	3.4
• Crude Oil	42,291	43,080	45,578	1.9	5.8
• Coal	14,908	14,993	13,406	0.6	-10.6
• Petroleum products	1,862	1,429	3,174	-23.3	122.0
• Natural gas	14,064	14,812	14,350	5.3	-3.1
• Condensate	1,512	1,329	1,655	-12.1	24.5
• Electricity	2,518	2,842	3,023	12.9	6.4
Traditional RE	44	42	0	-4.5	-100.0

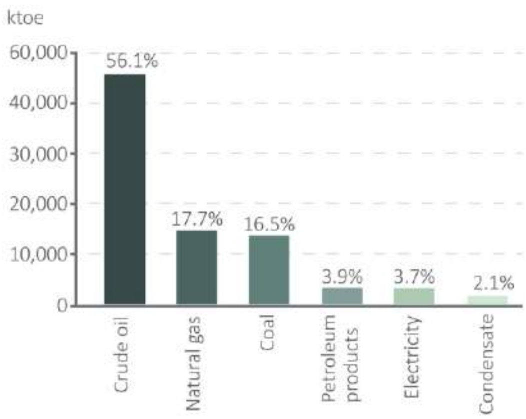


Figure 1-6: Thailand's energy import in 2022 (DEDE, 2024)

In 2022, total energy exports of Thailand amounted to 8,991 ktoe, a decrease of 20.8% from the previous year. About 90.0% of total energy exports were petroleum products, a decrease of 20.7% from the previous year (see Figure 1-7).

EXPORT OF ENERGY	QUANTITY (ktoe)			GROWTH (%)	
	2020	2021	2022	2021	2022
Total Energy Production	10,812	11,358	8,991	5.1	(20.8)
Commercial Energy	10,800	11,343	8,991	5.0	(20.7)
• Petroleum products	9,253	10,242	8,024	10.7	(21.7)
• Crude Oil	1,230	808	671	(34.3)	(17.0)
• Electricity	222	170	176	(23.4)	3.5
• Natural Gasoline	51	22	2	(56.9)	(90.9)
• Coal	44	101	118	129.5	16.8
Traditional RE	12	15	0	25.0	(100.0)
Biofuel	-	-	-	-	-

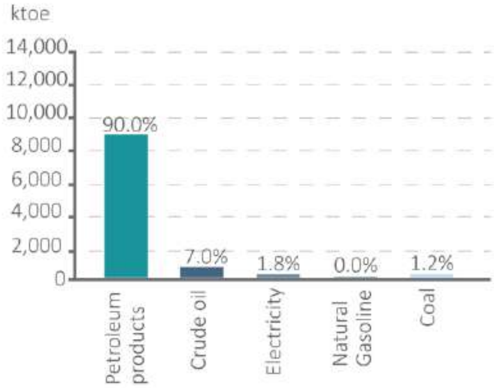


Figure 1-7: Thailand's energy export in 2022 (DEDE, 2024)

1.2.4 Alternative energy

In 2022, total alternative energy consumption of Thailand was 11,524 ktoe, an increase of 10.2% from the previous year. Solar, biomass, municipal solid waste (MSW) and biogas were the primary sources used to generate heat, accounting for 6,294 ktoe, or 54.6% of total alternative energy consumption–a 20.2% increase compared to the previous year. Moreover, solar, wind, hydro, biomass, MSW, biogas and geothermal used to generate electricity accounted for 28.9% of total alternative energy consumption. Biofuel from ethanol and biodiesel constituted 16.5% of total alternative energy consumption (see Figure 1-8).

ALTERNATIVE ENERGY CONSUMPTION	QUANTITY (ktoe)				GROWTH (%)
	2019	2020	2021	2022	2022
1. Electricity (Solar, Wind, Hydro, Biomass, MSW, Biogas and Geothermal Power)	3,239	2,903	3,090	3,324	7.6
2. Heat (Solar, Biomass, MSW and Biogas)	8,525	6,717	5,238	6,294	20.2
3. Biofuel					
• Ethanol	829	765	690	716	3.8
• Biodiesel	1,543	1,612	1,441	1,190	-17.4
Total	14,136	11,997	10,459	11,524	10.2

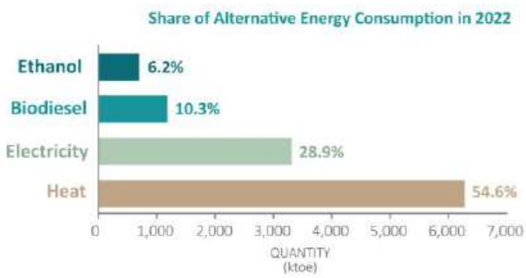


Figure 1-8: Thailand's alternative energy consumption in 2022 (DEDE, 2024)

1.3 NATURAL RESOURCES

Thailand is rich in natural resources, which play a key role in supporting local lifestyles and driving economic growth. Forests, watersheds, marine and other natural resources are important to support Thailand's manufacturing, export and tourism industries.

1.3.1 Land resources and Land use

Land resources are important for the survival of humans, plants, and animals, as well as being important to the national economy and development. The total area of Thailand is 320,696,893 rai or 513,115 (Sq. km.) Land is categorized as follows:

1) High agricultural potential: This accounts for about 46.4% of the total country area.
2) Low agricultural potential: This accounts for about 18.7% of the total country area. This category can be attributed to two main factors, which are (1) natural properties, i.e. saline soil, acidic soil, sandy soil, etc. and (2) inappropriate land use, i.e. hard soil, contaminated soil, abandoned mines, shrimp farms, erosion, etc.
3) Steep terrain: This accounts for about 31.7% of the total country area. Most of the area is sloped mountain and more than 35.0% of the area is covered with various types of forests. Some areas are used for agriculture and residences.
4) Miscellaneous lands: The remaining 3.3% of the country, this part is unsuitable for agriculture, and it is used for purposes such as airports, cemeteries and beaches.

During 2019–2021, most land in Thailand was used for agricultural activities (about 178 million rai), followed by forest (104 million rai), community areas and buildings (20 million rai), water resources (10 million rai), and others. Land use has considerably changed, compared to the period of 2017–2018. Community areas and buildings increased by 5.6% due to residential and industrial expansion. Water resources increased by 4.8%. On the other hand, miscellaneous areas, forestry and agricultural land decreased by 2.4%, 0.5% and 0.4%, respectively. However, during the past 11 years, forestry and agricultural land change were merely steady while community areas and buildings and water resources had increased, substituting for miscellaneous areas (see Table 1-2) (ONEP, 2023).

Table 1-2: Land area of Thailand, classified by land use (ONEP, 2023)

Types of land use	Area (Million Rai)				Land use change between 2017-2018 and 2019-2021	
	2010 - 2013	2015 - 2016	2017- 2018	2019 - 2021	Area (Million Rai)	Percentage
Communities and buildings	16.5	17.9	18.7	19.8	+1.04	+5.55
Agriculture	174.3	177.6	178.7	178	-0.76	-0.43
- Rice fields	77.1	74.3	71.5	69	-2.46	-3.44
- Crops	40.7	41.3	43.8	45.4	+1.55	+3.54
- Perennial plants	36.4	42.9	44.6	44.6	+0.03	+0.07
- Fruits	11.2	10.3	10.4	10.9	+0.45	+4.32
- Rotating crops	4.0	4.3	3.8	3.4	-0.44	-11.46
- Aquaculture facilities	2.9	2.7	2.7	2.8	+0.09	+3.28
- Others (Horticulture, pasture, aquatic plants)	1.9	1.9	1.9	1.9	+0.01	+0.53
Forest area	109.3	105.9	104.7	104.1	-0.53	-0.51
Water area	9.0	9.3	9.4	9.8	+0.45	+4.80
Miscellaneous area	11.6	10.1	9.2	9	-0.22	-2.39
Total	**320.7**	**320.7**	**320.7**	**320.7**		

1.3.2 Minerals

Minerals are basic natural raw material of industries that are important for the development of the country's economy. Changes in mineral resources have been driven by urban and large-scale infrastructure development, increasing demand for construction materials. Demand for Thailand's non-metallic minerals, especially cement, has been growing in both the industrial and construction sectors.

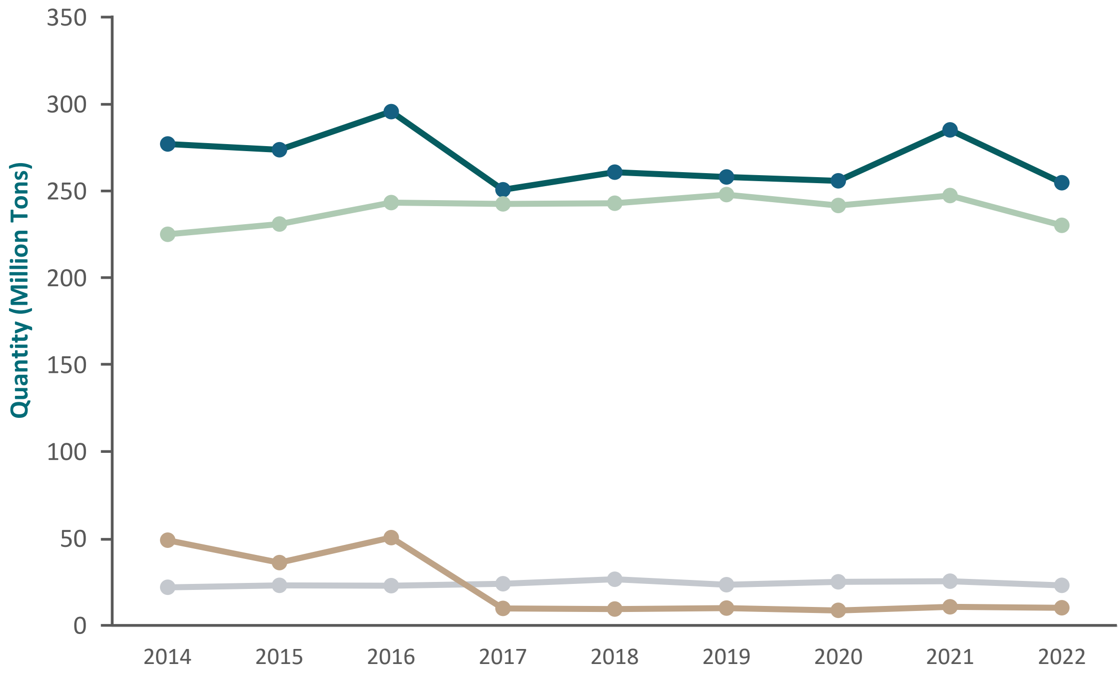
Thailand has more than 40 mineral resources, classified into 10 industrial groups, including

1) fuel, such as coal, about 2,000 million tons;
2) industrial stone, such as greywacke, granite, quartz, quarry, limestone, cement, sandstone, Nile, basalt, marble, rhyolite and andesite, about 9,535 billion tons;
3) ornamental stones, about 70,605 million cubic meters, such as granite, sandstone, pebble, travertine, Nile and marble;
4) cement industry, about 1,244 billion tons, such as cement, gypsum and clay;
5) precious metals such as gold about 213 tons;
6) basic metals, about 301 million tons, such as tin, lead, copper and antimony;
7) iron and iron alloys, about 145 million tons, such as iron and manganese;
8) ceramic industry, about 102 billion tons, such as quartz, dickite, dolomite, glass, kaolin, ball clay and feldspar;
9) other industrial minerals, about 19,268 billion tons, such as rock salt, calcite, talc, bentonite, barite, perlite, potash, pyrophyllite, fluoride, and limestone, and
10) light metal and rare earths about 5 million tons.

In Thailand's mineral resources, rock salt (18 trillion tons) has the highest quantity, followed by limestone (9 trillion tons), potash (400 billion tons) and sandstone (200 billion tons). In 2022, mineral production was 255.14 million tons, a decrease of 10.7% from the previous year. The highest mineral production values were limestone, coal, gypsum and rock salt. About 230.61 million tons of minerals were used in Thailand. Limestone was a major mineral utilized in construction and cement industries, followed by coal utilized in the power generation industry.

Thailand imported 23.48 million tons of minerals, a decrease of 9.2% from the previous year. Fuel minerals, such as sub-bituminous, bituminous and lignite, utilized in power generation and other industries, were the primary imports, accounting for about 70.0% of total mineral import value. For the remainder, Thailand imported both metallic and non-metallic minerals such as niobium, vanadium, and flintstone.

Most mineral exports were non-metallic, accounting for around 10.5 million tons, a decrease of 5.0% from the previous year. Gypsum had the highest mineral export quantity as Thailand has continuously been the world largest exporter. The main export markets were Indonesia, Vietnam, Malaysia and Japan. Additionally, other mineral exports were anhydrite, dolomite, sodium feldspar and limestone. However, tin had the highest mineral export value, followed by gypsum and monazite (see Figure 1-9) (ONEP, 2023).



	2014	2015	2016	2017	2018	2019	2020	2021	2022
Production	277.38	274.06	296.19	251.14	161.17	258.49	256.26	285.64	255.14
Usage	225.50	231.42	243.79	242.94	243.29	248.30	242.05	247.82	230.61
Import	22.27	23.36	23.18	24.41	26.95	23.71	25.41	25.87	23.48
Export	49.47	36.53	50.96	10.10	9.87	10.31	8.96	11.05	10.50

Figure 1-9: Quantity of mineral production, utilization, import and export during 2014–2022 (ONEP, 2023)

1.3.3 Forestry and wildlife

In 2022, Thailand's forestry area was 102,135,974.96 rai, accounting for 31.6% of the country area (see Figure 1-10). During the past decade, forest areas of Thailand have remained relatively stable. Most forests are in the northern area of Thailand, accounting for about 63.7% of the total area in the northern region, followed by the west, northeast, and central areas (see Table 1-3). By comparison between the year 2022 and 2021, forest area increased in the central and southern regions. Degradation of forest area in Thailand was the result of land use changing to agriculture, buildings and community areas.

Degradation of forests and wildlife has been driven by economic development, as well as urban and tourism expansion, leading to more construction of roads and infrastructure for accommodation, facilitating occupation, tourist attractions and other demand responses. These resulted in destruction of natural habitats of wildlife and transformation of biodiversity in the ecosystem. Also, forest fires are another severe problem, occurring in many areas each year from both natural and human causes, resulting in instability of ecosystems and biodiversity as well as human quality.

In 2022, there were 2,371 fires extinguished in 38,245.6 rai of forest, a decrease of about 45.0% from the previous year. The main causes were from land conversion, forest foraging, and field burning. However, according to the statistical information during the past five years, the trends of forest fires and burned forest area have declined.

Wildlife is a valuable resource for the ecosystem and is an indicator of richness of forest and bio- and genetic diversity. In Thailand, the Wildlife Conservation and Protection Act, B.E. 2562 (2019) has been employed to protect and conserve wildlife. There are 1,316 species of protected wildlife, classified into mammals (202 species), birds (952 species), reptiles (92 species), amphibians (12 species), fish (26 species), insects (20 species), and other vertebrates (12 species). Important wildlife of Thailand, and of international interest, are tigers (*Panthera Tigris*) and elephants (*Elephas Maximus*). In 2022, around 120 tigers (*Panthera Tigris)* were found in World Heritage areas such as Thung Yai Naresuan-Huai Kha Khaeng and Dong Phayayen-Khao Yai Forest. From the exploration, it is expected that the number of tigers in natural areas will increase. In addition, around 4,013 – 4,422 elephants (*Elephas Maximus)* were found in many natural areas of Thailand.

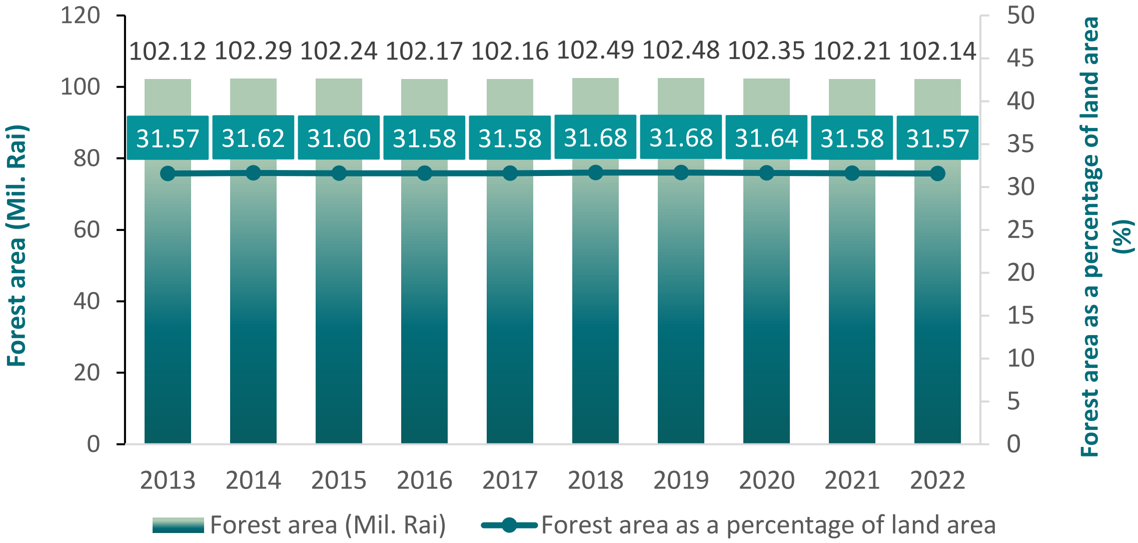


Figure 1-10: Forest area of Thailand during the period of 2013–2022 (ONEP, 2023)

Table 1-3: Change of forestry by each region of Thailand during the period of 2021–2022 (ONEP, 2023)

Regions	Province area (Rai)	2021		2022		Area change (+/-)	
		Forest area (Rai)	%	Forest area (Rai)	%	Forest area (Rai)	%
Central	56,912,646	12,240,542	21.51	12,273,419	21.57	32,877	0.27
East	21,550,884	4,721,202	21.91	4,711,228	21.86	-9,974	-0.21
North	60,048,349	38,228,700	63.66	38,147,662	63.53	-81,038	-0.21
North-East	104,823,709	15,702,388	14.98	15,695,706	14.97	-6,682	-0.04
South	46,154,901	11,218,546	24.31	11,224,485	24.32	5,939	0.05
West	34,038,210	20,101,055	59.05	20,083,474	59.00	-17,581	-0.09
Whole country	**323,528,699**	**102,212,433**	**31.59**	**102,135,974**	**31.57**	**-76,459**	**-0.07**

1.3.4 Water

Thailand has 22 major river basins and 27 groundwater sources. The country has experienced problems with water resources such as water shortages, drought, floods, decreased groundwater levels, and saltwater intrusion in groundwater sources. Severe droughts that occurred in 1979, 1994, and 1999 affected every part of the country. There have been an increasing number of recurring droughts over the last 10 years, which have affected a total area of 42,280 km^2.

Transformation of water resources of Thailand has been driven by the rapid expansion of cities, economics, industries, technology and infrastructure. Development in various sectors has resulted in increasing water demand, especially for agriculture tourism and industry. Also, weather variations such as unusual seasonal and spreading rain have impacted water supplies and consumption, agricultural use and conservation of ecosystems. On the other hand, accumulated heavy rain for a long time damages both property and people's livelihoods.

Sources of water in Thailand can be divided into 4 types: rain, runoff, reservoir and groundwater. During the past decade, the trend of average precipitation level has increased. However, low precipitation levels in some areas results in shortages in water storage. In 2022, natural runoff volume was around 228,778 cubic meters (m^3), a decrease of 3.3% from the previous year. The highest average runoff volume was in the southern area, followed by the northeastern, northern, central and eastern areas (see Table 1-4).

Table 1-4: Runoff volume by region of Thailand during 2017–2022 (ONEP, 2023)

Unit: Cubic meters

Regions	Watershed area (km^2)	Year					
		2017	2018	2019	2020	2021	2022
Central	98,473	36,936	32,835	20,531	32,082	41,490	33,078
East	36,438	24,433	22,098	21,587	26,448	31,598	27,958
North	128,448	41,661	35,716	25,203	30,276	42,995	43,237
North-East	176,602	54,741	42,990	34,899	41,400	48,074	49,355
South	71,401	72,270	63,683	50,764	69,733	72,515	75,151
Whole country	**511,362**	**230,042**	**197,321**	**152,985**	**199,939**	**236,672**	**228,779**

In 2022, the total volume of water in reservoirs (including large and medium sizes) was 43,692 m^3. For the large reservoirs, the volume of water was 40,578 m^3, an increase of 19.8% from the previous year, and around 42.0% of the total volume was used. For the medium reservoirs, the volume of water was 3,114 m^3, an increase of 21.4% from the last year, and 87.3% of the total volume was used.

Potential groundwater in Thailand is 1,137,712 million m^3 per year. The biggest resource is in the central area with 36.3 % of total stored groundwater, followed by the northeast (21.2%), south (17.6%), north (14.7%), west (5.6%) and east (4.7%) (see Table 1-5).

Table 1-5: Potential of groundwater by region of Thailand (ONEP, 2023)

Regions	Whole country Area (km^2)	Volume of groundwater (Cubic meters per year)		
		Storage	Annual supplement	Safely useable
Central	90,359	412,855	11,087	7,421
East	34,329	53,198	6,655	4,663
North	95,801	166,861	11,823	5,291
North-East	167,125	241,310	22,499	15,845
South	70,028	199,778	15,237	9,452
West	54,103	63,710	5,687	2,718
Whole country	**511,745**	**1,137,712**	**72,988**	**45,390**

1.3.5 Coastal line and marine

Thailand has 24 coastal provinces, with a total area of 101,678 km^2 and a coastline of 3,151 km. The total maritime territory is 321,247 km^2, consisting of internal waters (61,023 km^2), territorial seas (52,216 km^2), contiguous zones (37,185 km^2), exclusive economic zones (163,644 km^2), and Thai-Malaysia joint development area (7,179 km^2).

In 2021, 823.06 km of Thailand's coastline faced erosion problems. The eroded areas with high, medium and low severities were 29.88 km, 26.79 km and 13.07 km, respectively. Marine and coastal resources entail 2,779 km^2 of mangroves, 256 km^2 of seagrass, 238 km^2 of coral reefs, 971 islands, and 609 beaches. The coastal area and marine resources have been adversely affected by climate change impacts and expanding economic activities, causing many critical problems such as coastal erosion, coral bleaching, acidification of seawater, degradation of coral reefs and seagrass, depletion of marine animals, and increased marine plastic litter. Thailand has a large area of mangrove forest, scattered in the eastern, central and southern coastal areas within 24 provinces. In 2020, according to high-resolution satellite images, 1,737,020 rai of mangrove forest in good condition existed, an increase of 12.93% from 2017–2018. (see Figure 1-11) The trend of mangrove forest areas has increased continuously due to the government's measures to prevent forest encroachment and support awareness of forest conservation.

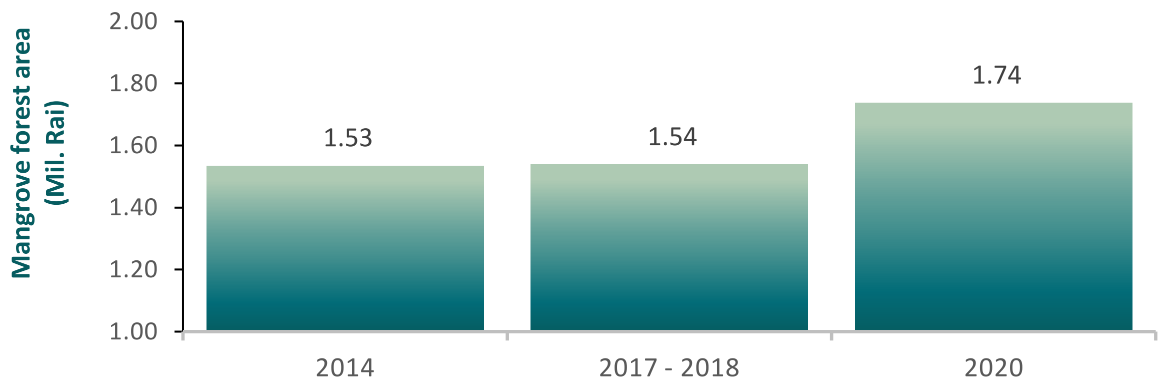


Figure 1-11: The mangrove forest areas remaining in good condition from the high-resolution satellite images in 2020 (ONEP, 2023)

In 2022, Thailand had 149,182 rai of coral reefs, divided between the Andaman Sea (73,756 rai) and the Gulf of Thailand (75,426 rai). There were 280 species, dispersed across 17 provinces. Around 53.0% of overall coral reefs were in good condition while another 25.0% were deteriorated, and the remaining were in moderate condition. In addition, the condition of those in the Andaman Sea was better than in the Gulf of Thailand. However, even though coral bleaching was low in severity during the end of April to early May of 2022, bleaching increased in some areas with different severity levels in 2023.

1.3.6 Biodiversity

Thailand is one of the most biodiverse countries in Southeast Asia. According to the ONEP's report on Thailand's biodiversity status in 2020, national biodiversity can be classified into four groups:

1) Ecosystems: Seven types of Thailand's ecosystems are forest, mountain, agriculture, marine and coastal, island, inland water, and dry and semi-humid.
2) Plant species: From the publication of Flora of Thailand in 2017, Thailand hosted around 12,050 plant species. Later, various national and international botany journals on plant taxonomy published from 2014 to 2020 revealed 239 new plant species in Thailand.
3) Animal species: There were more than 3,203 invertebrate species (including corals, crustaceans, and mollusca) and 5,005 vertebrate species in 2020, an increase of 274 species from 2017. Of all the invertebrate species, 302 are listed as threatened species, with 7 critically endangered, 62 endangered and 233 vulnerable. In addition, of all the vertebrate species, 676 are listed as threatened species, with 141 critically endangered, 191 endangered, and 344 vulnerable.
4) Microorganism species: There are over 200,000 species that are diverse in terms of species, genetic, and ecological contexts.

Biodiversity conditions in Thailand are threatened by the increased socio-economic activities and climate change impacts which may cause severe biodiversity loss and degraded ecosystems. The Office of Natural Resources and Environmental Policy and Planning (ONEP), as a national focal point of the Convention on Biological Diversity (CBD), has initiated many programs to fulfill the commitments under the CBD, such as developing the Post-2020 Biodiversity Framework, organizing activities for the International Day for Biological Diversity 2020, formulating the Fifth Global Biodiversity Outlook: GBO5, and organizing the Summit on Biodiversity and other related meetings.

For domestic operations, ONEP has worked as a secretary in the National Committee on Conservation and Utilization of Biodiversity, responsible for proposing guidelines, policies, measures, and plans for the conservation and exploitation of the country's biodiversity to the Cabinet, including providing policy recommendations for integrating and linking strategic operations under the plan to achieve goals and maneuvering the Integrated Biodiversity Management. The Master Plan adopted the National Biodiversity Action Plans 2023-2027 as a framework for the operation's direction, focusing on conservation, restoration, protection, and exploitation of biodiversity and ecosystem services.

1.4 STATE OF ENVIRONMENT

Thailand is in the Northen Hemisphere and tropical zone. Its climate consists of three seasons: summer, rainy and winter, except for the southern area. Summer is from mid-February to mid-May, with the highest temperatures in April. The rainy season is from mid-May to mid-October due to the southwest monsoon. The winter season, caused by the northeast monsoon, is from mid-October to mid-February and impacts all of Thailand except the southern region.

1.4.1 Temperature

The historical trend of Thailand's climate data shows the annual mean maximum temperature (Figure 1-12), the annual mean minimum temperature (Figure 1-13), and the annual mean temperature (Figure 1-14). The upward trendlines show that the temperature in Thailand has been increasing over the past decades. This trend may reflect the impact of climate change which could contribute to more frequent and intense heat events, impacting various sectors and ecosystems in Thailand.

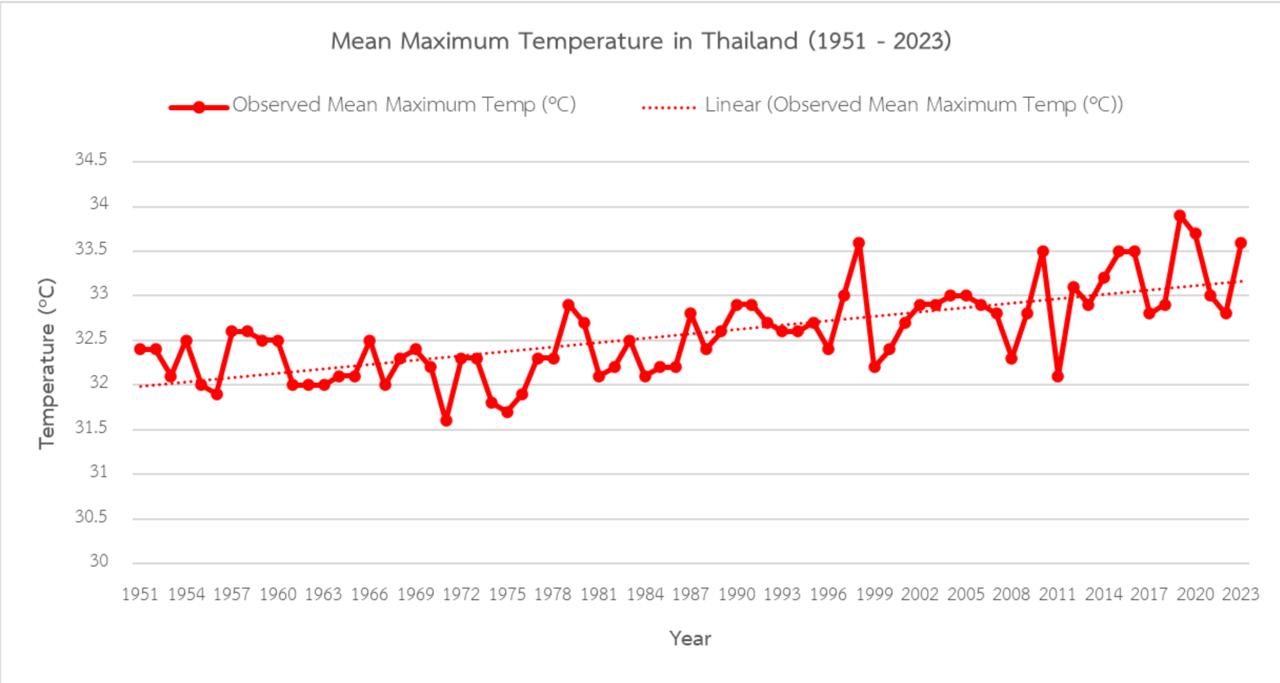


Figure 1-12: Mean maximum temperature in Thailand from 1951 to 2023 ((TMD, 2021b), (TMD, 2022b), (TMD, 2023b) and (TMD, 2024a))

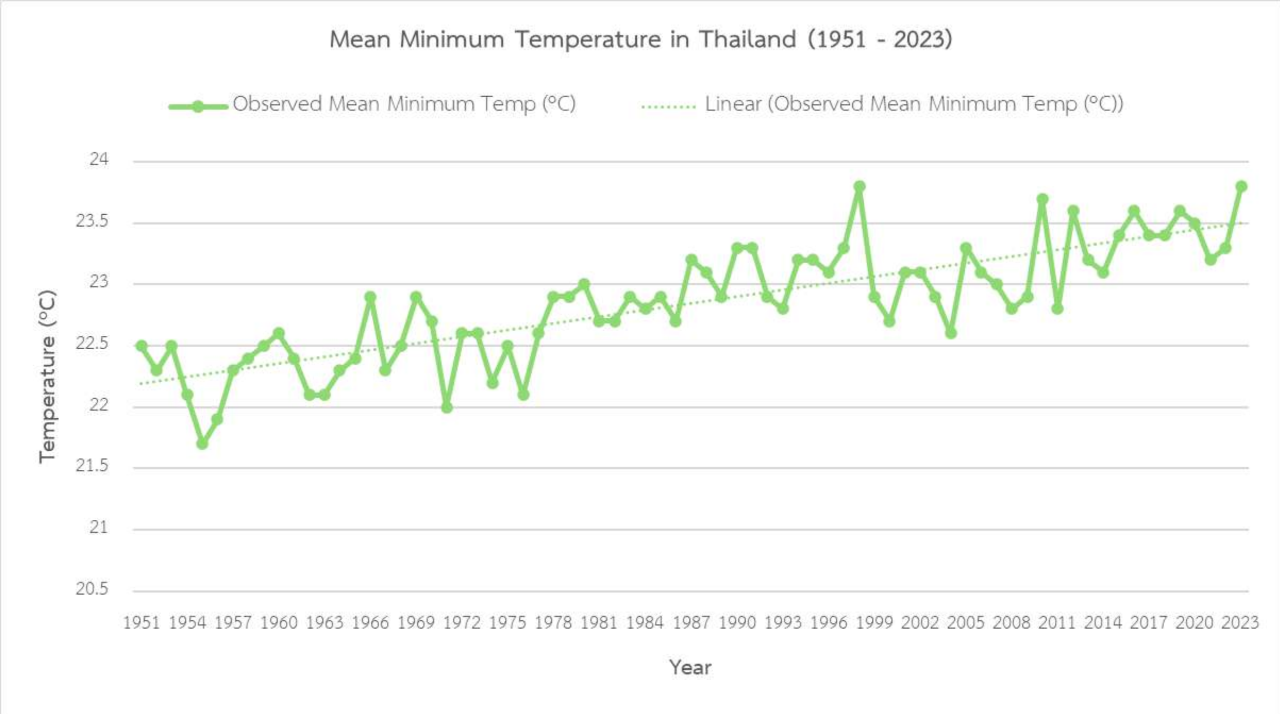


Figure 1-13: Mean minimum temperature in Thailand from 1951 to 2023 ((TMD, 2021b), (TMD, 2022b), (TMD, 2023b) and (TMD, 2024b))

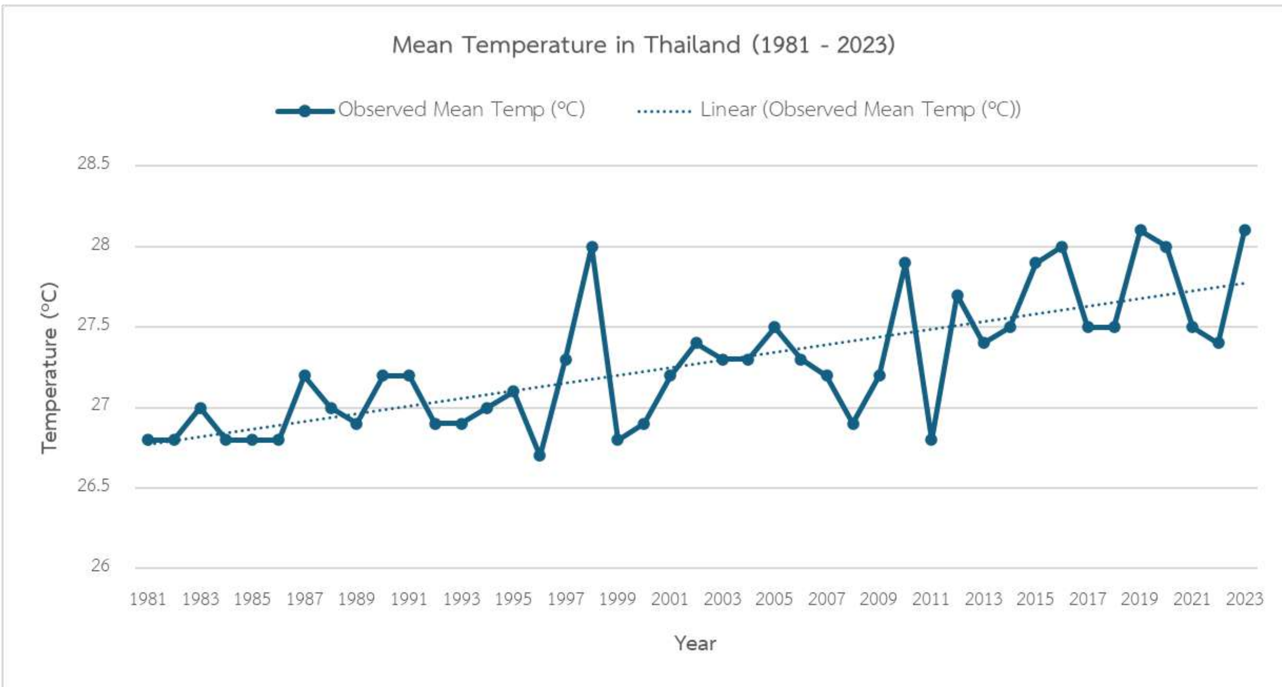


Figure 1-14: Annual mean temperature in Thailand from 1981 to 2023 ((TMD, 2021b), (TMD, 2022b), (TMD, 2023b) and (TMD, 2024d))

The Department of Climate Change and Environment (DCCE) conducted a study on Thailand's projected temperature. They considered three cases in their analysis: mean temperature increases of 1°C, 1.5°C, and 2°C, respectively, relative to the base years of 1970-2005. They used three general circulation models (GCMs), namely MPI-ESM-MR, EC-Earth, and HadGEM2-ES, in their study. Please see the detail in the NAP under Projected Trends in Temperature topic (DCCE, 2023).

1.4.2 Precipitation

The historical precipitation pattern in Thailand shows the trend in annual mean rainfall. The figure shows that the variation of precipitation and the number of rainy days has oscillated over time. In the last decade, rainfall variation has been particularly pronounced. The lowest rainfall in 40 years was recorded in 2019 at 1,343.4 mm, while the highest annual rainfall was recorded in 2017, with 2,017 mm of precipitation (Figure 1-15). Provinces with a trend of significantly increasing rainfall are mostly located in the western, northern, and upper northeastern regions. In contrast, provinces with a trend of significantly decreasing rainfall are primarily in the northeastern region. As a result, the agricultural sector may face more severe droughts, while urban communities may experience heavy rainfall and flash floods. The detail of Projected Trends in Precipitation topic provided in the NAP (DCCE, 2023).

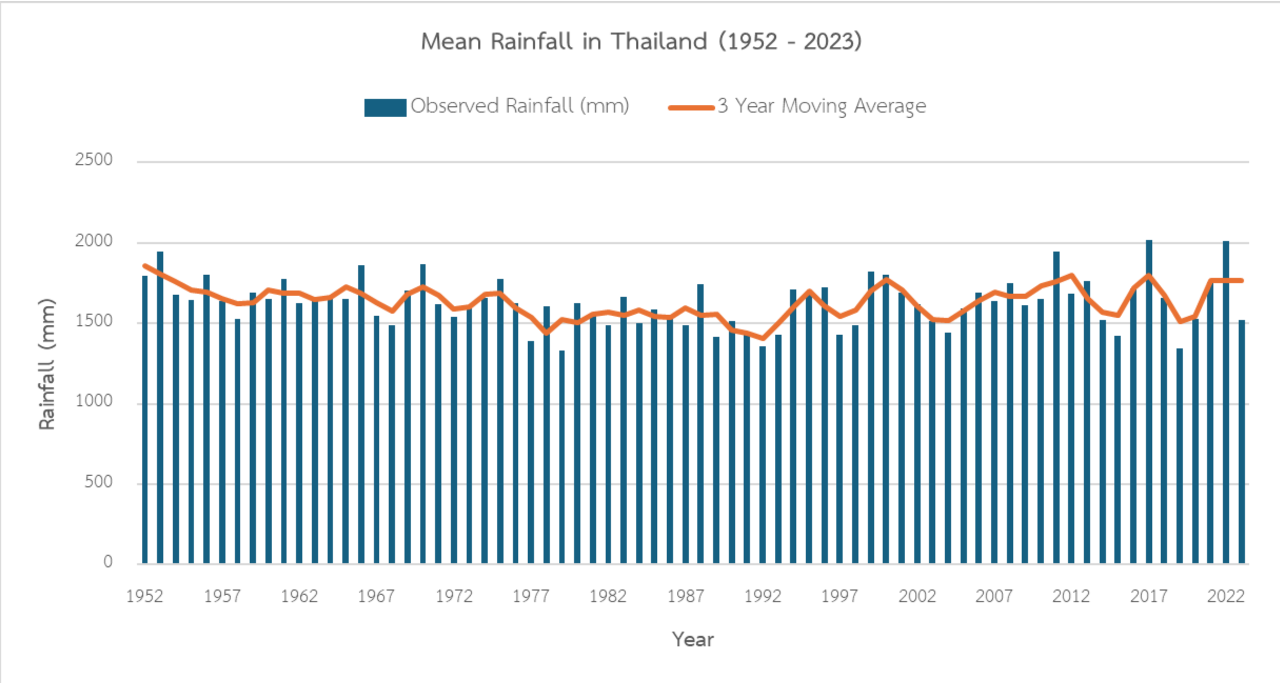


Figure 1-15: Mean Annual Rainfall (mm) in Thailand from 1952 to 2023 ((TMD, 2020), (TMD, 2021a), (TMD, 2022a), (TMD, 2023a) and (TMD, 2024c))

1.4.3 Air quality

Economic growth is the main factor affecting air quality in Thailand. Development of mass transit systems, residences, agricultural areas, urbanization, etc., to support economic growth and expansion after Covid-19 resulted in a positive direction for the tourism economy. However, both the industrial and agricultural production process still release waste into the environment bringing about air pollution in Thailand.

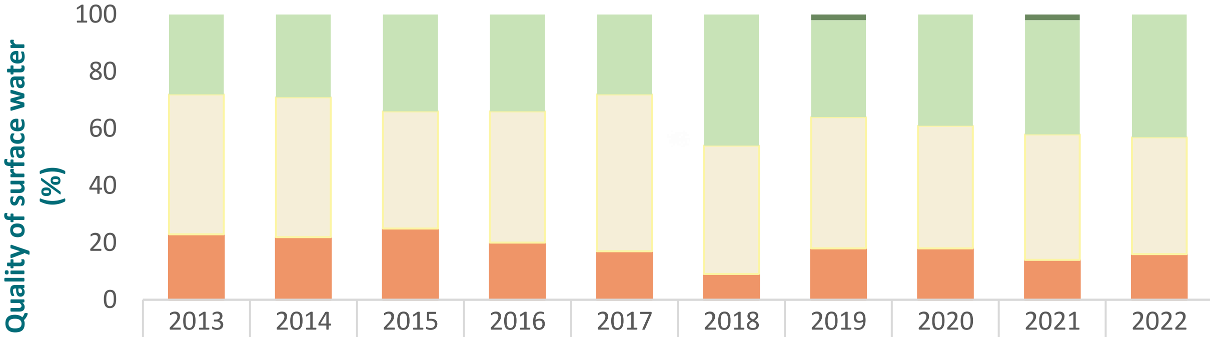
Every winter, high pressure or cold stream from China spreads down to cover Thailand, resulting in calm wind and low air circulation. Dust produced from many activities in the country, for example agricultural waste burning, construction, and fuel combustion, is accumulated in the air. In addition, changes of climate, such as drought and unstable weather during the winter season, intensifies accumulation of dust particles.

In the overall perspective of the whole country, in 2022, air quality was improved from the previous year. The average amount of particulate matters 2.5 (PM2.5) and 10 (PM10) microns decreased by 5%, compared to 2021. PM2.5, PM10 and Ozone (O_3) were higher than the standard in many provinces while Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Carbon Monoxide (CO) were under the standard and lower than the year before (PCD, 2023).

1.4.4 Water quality

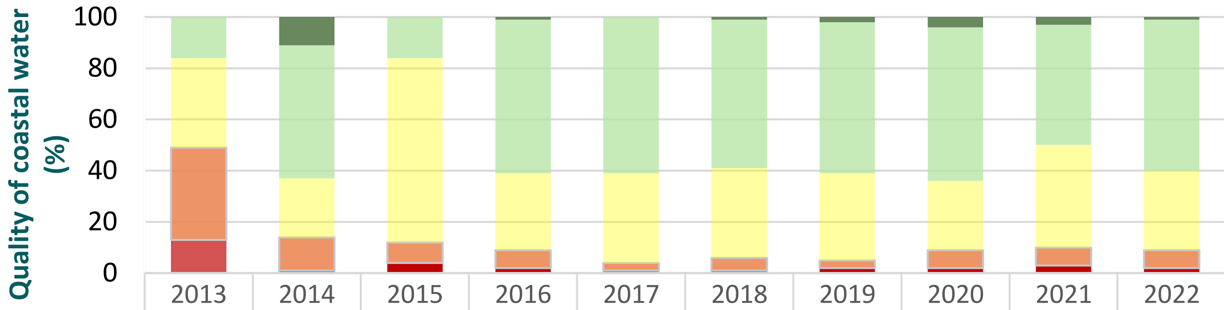
Surface water: Of 61 water sources and 9 still water resources in 2022, 43% were good quality, 41% were fair quality, and 16% were poor quality. None was very poor quality (see Figure 1-16).

Coastal water: In 2022, 59% of coastal water was of good quality, 31% of fair quality, and 7% of poor-quality. (see Figure 1-17)



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Excellent	0	0	0	0	0	0	2	0	2	0
Good	28	29	34	34	28	46	34	39	40	43
Average	49	49	41	46	55	45	46	43	44	41
Poor	23	22	25	20	17	9	18	18	14	16

Figure 1-16: State of surface water quality: 2013-2022 (ONEP, 2023)



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Excellent	0	11	0	1	0	1	2	4	3	1
Good	16	52	16	60	61	58	59	60	47	59
Average	35	23	72	30	35	35	34	27	40	31
Poor	36	13	8	7	3	5	3	7	7	7
Very poor	13	1	4	2	1	1	2	2	3	2

Figure 1-17: State of coastal water quality: 2013-2022 (ONEP, 2023)

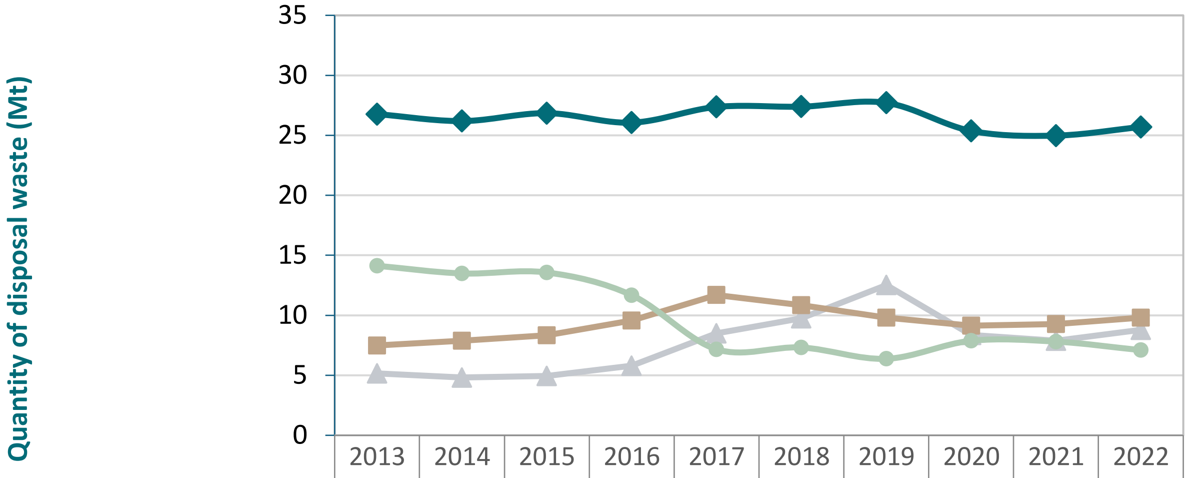
1.4.5 Waste

Solid waste: In 2022, the amount of solid waste was 25.70 million tons, an increase of 2.9% from 2021 (see Figure 1-18). The municipal solid waste sorted at the sources and recycled was 8.80 million tons, waste properly disposed was 9.80 million tons, and improperly disposed waste was 7.10 million tons.

Plastic: In 2022, the number of single-use plastics was 2.83 million tons, or about 11.0% of total solid waste in Thailand, the highest amount following food waste.

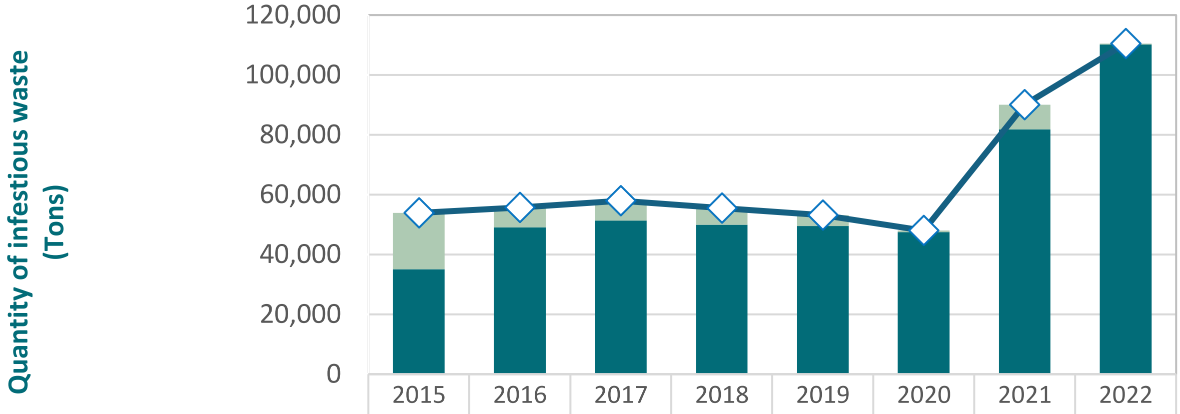
Hazardous waste: In 2022, household hazardous waste was approximately 676,146 tons (an increase of 1.0% from 2021). Most wastes were electrical and electronic equipment, with 439,495 tons (about 65%). Other types of hazardous wastes were batteries, dry cell batteries, chemical containers, and aerosol spray cans with 236,651 tons (about 35%). From the government policies on supporting the household hazardous waste management system, Local Administration Organizations and related organizations had to provide collection points of household hazardous wastes in the community and collection centers at provincial levels. As a result, 12.9% of household hazardous wastes were managed properly, which is still an insignificant proportion. The mismanagement of household hazardous waste is caused by the lack of awareness, non-separation of hazardous wastes from general wastes, no regulations to enforce household hazardous wastes management, and no law to oversee the management of wastes from electric and electronic equipment.

Infectious waste: In 2022, the amount of infectious waste was 110,427 tons, a 22.68% increase from 2021 (see Figure 1-19). Infectious was caused by hospitals under the Ministry of Public Health, hospitals under the Department of Academic Affairs under the Ministry of Public Health, Sub-district Health promotion hospital, hospitals affiliated with other ministries, private hospitals, private clinics, animal hospitals, dangerous infection laboratories, and other sources. Infected waste of 110,125 tons, or 99.73% of total infected waste, was properly disposed (ONEP, 2023).



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total disposal solid waste	26.77	26.19	26.85	26.06	27.37	27.39	27.71	25.37	24.98	25.70
Recycling disposal waste	5.15	4.82	4.94	5.81	8.51	9.76	12.52	8.36	7.89	8.80
Proper disposal waste	7.49	7.88	8.34	9.57	11.69	10.85	9.81	9.13	9.28	9.80
Improper disposal waste	14.13	13.49	13.57	11.68	7.17	7.32	6.38	7.88	7.81	7.10

Figure 1-18: The amount of solid waste generated, the recycling, proper and improper disposal for the year 2013-2022 (ONEP, 2023)



	2015	2016	2017	2018	2019	2020	2021	2022
Improper disposed infectious waste	18,854	6,590	6,654	5,599	3,711	522	8,235	302
Proper disposed infectious waste	35,014	49,056	51,300	49,898	49,462	47,440	81,773	110,125
Total infectious waste	53,868	55,646	57,954	55,497	53,173	47,962	90,009	110,427

Figure 1-19: Amount of infectious waste: 2013-2022 (ONEP, 2023)

1.5 IMPACTS, RISKS AND VULNERABILITIES

1.5.1 Current and Projected Climate Trends and Climate Hazards

1.5.1.1 Sea Level

Sea level changes in Thailand have been monitored using two main sources: coastal measuring stations and satellite altimetry. The global sea level has been rising at an average rate of 2.8 mm per year (measured by stations) to 3.2 mm per year (measured by satellites) (Church & White, 2011; Nerem, et al., 2018). In Thailand, most data are derived from measuring stations, focusing on relative sea level changes. The upper Gulf of Thailand has experienced higher relative sea level increases compared to other areas, largely due to land subsidence from extensive groundwater pumping for public consumption. Additionally, vertical ground movements following the 2004 tsunami have further contributed to variations in the relative sea level. Climate change is projected to raise sea levels in Thailand. Scientists estimate that the Upper Gulf of Thailand will rise by 0.94 - 1.05 mm per year under RCP4.5 and by 1.07 - 1.18 mm per year under RCP 8.5 (Jaroenongard, et al., 2021). Sea level rise can worsen the impact of cyclones and storm surges by exacerbating the damage caused by higher storm surge levels, leading to increased coastal flooding and erosion.

1.5.1.2 Heatwave

Signs of heatwave events have already been observed in Thailand. Data from the Meteorological Department indicated that in April 2024, several provinces in the northeastern region experienced heat waves, with daily maximum temperatures exceeding the average maximum by more than 8 °C in some areas. A heat wave is defined as an event where the daily maximum temperature surpasses the area's average maximum by at least 5 °C for a consecutive period of at least five days.

Heatwaves are a serious threat to children in Thailand, as their bodies are less capable of regulating temperature compared to adults. Increased frequency and duration of heatwaves heighten the risk of various health problems for children, including chronic respiratory diseases, asthma, and cardiovascular issues. Infants and children are especially at high risk of death from heatwaves. Moreover, heatwaves and other climate crises pose barriers to children's access to essential services such as healthcare, education, and clean drinking water.

The United Nations Children's Fund (2022) reported concern about the prevalence of heatwaves in Thailand. In 2020, over 75% of children under 18 years old (10.3 million children) faced more frequent heatwaves. Projections indicate that by 2050, children in Thailand will experience more frequent and prolonged heatwaves if no action is taken. Additionally, a report from The Thailand Development Research Institute (2022) indicated that children in Thailand are highly vulnerable to climate change impacts, including extreme heat, floods, and drought. Children residing in the provinces of Ubon Ratchathani, Nakhon Ratchasima, Sisaket, Nakhon Si Thammarat, and Narathiwat are at the highest risk.

1.5.2 Observed and Potential Impacts of Climate Change

1.5.2.1 Past disasters in Thailand

From 2014 to 2023, Thailand experienced a range of natural disasters (Figure 1-20). The data reveals significant impacts in terms of impacted provinces, deaths, people affected, and damage across various types of disasters, including floods, droughts, landslides, windstorms, and others.

Disaster statistics in Thailand reveal that over the past 72 years, tropical cyclones have consistently entered Thailand, primarily as tropical depressions, with some years seeing tropical storms and typhoons. However, the overall frequency of cyclones has declined, largely due to a reduction in tropical depressions (Figure 1-21).

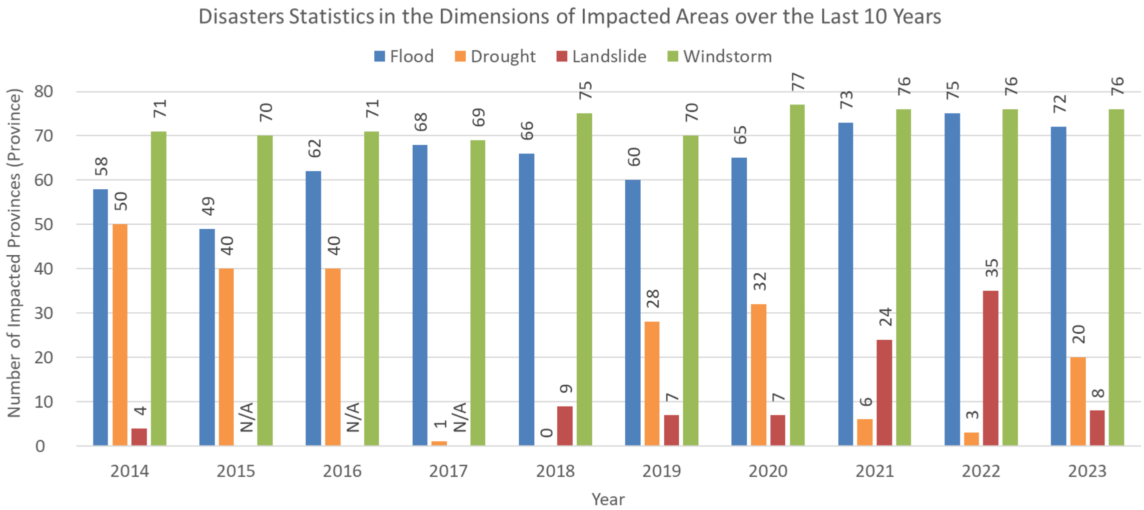


Figure 1-20: Number of impacted provinces of past disasters in Thailand (2014 – 2023) (DDPM, 2024a)

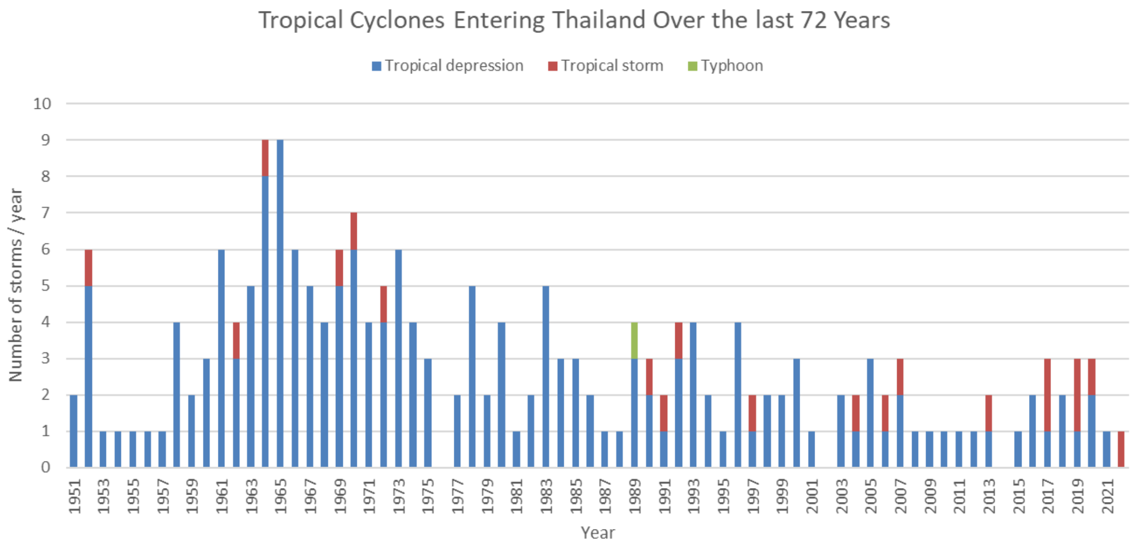


Figure 1-21: Number of tropical cyclones entering Thailand (1951 – 2022) (TMD, 2023c)

Data from the past 10 years shows that windstorms are the primary cause of provincial-level impacts, followed by floods and droughts, while landslides occur the least frequently. The number of affected households fluctuates each year, with droughts and floods often impacting a large number of households (Figure 1-22). Floods have also resulted in the highest reported fatalities (Figure 1-23). In terms of economic damage, droughts cause higher financial losses compared to floods, despite affecting fewer households. Therefore, droughts and floods can be considered a significant disaster that Thailand needs to address and mitigate to reduce disaster risks (Figure 1-24 and Table 1-6).

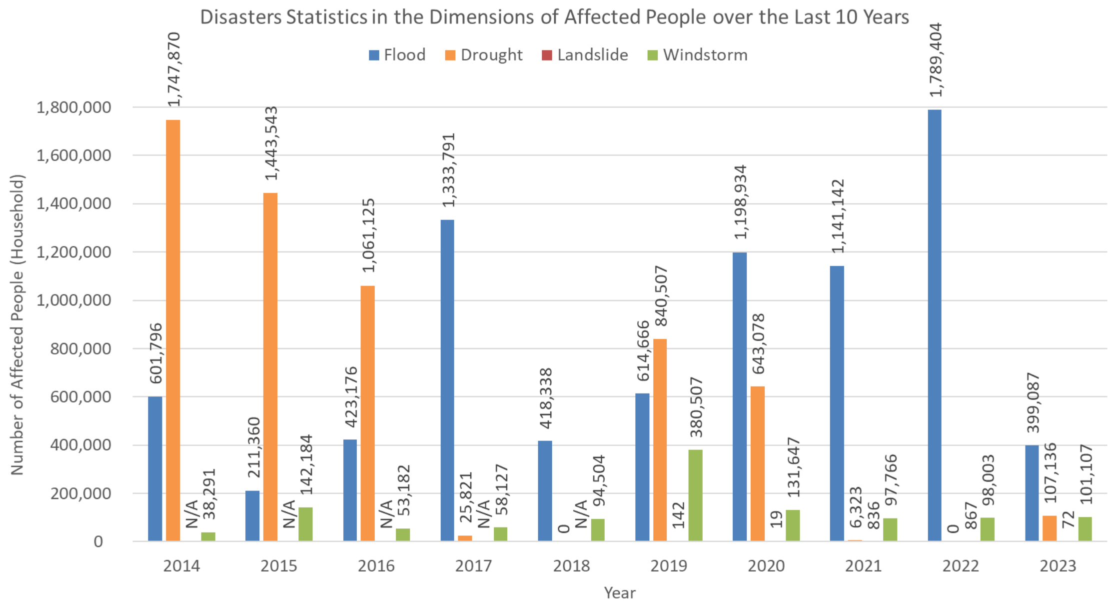


Figure 1-22: Number of affected people of past disasters in Thailand (2014 – 2023) (DDPM, 2024a)

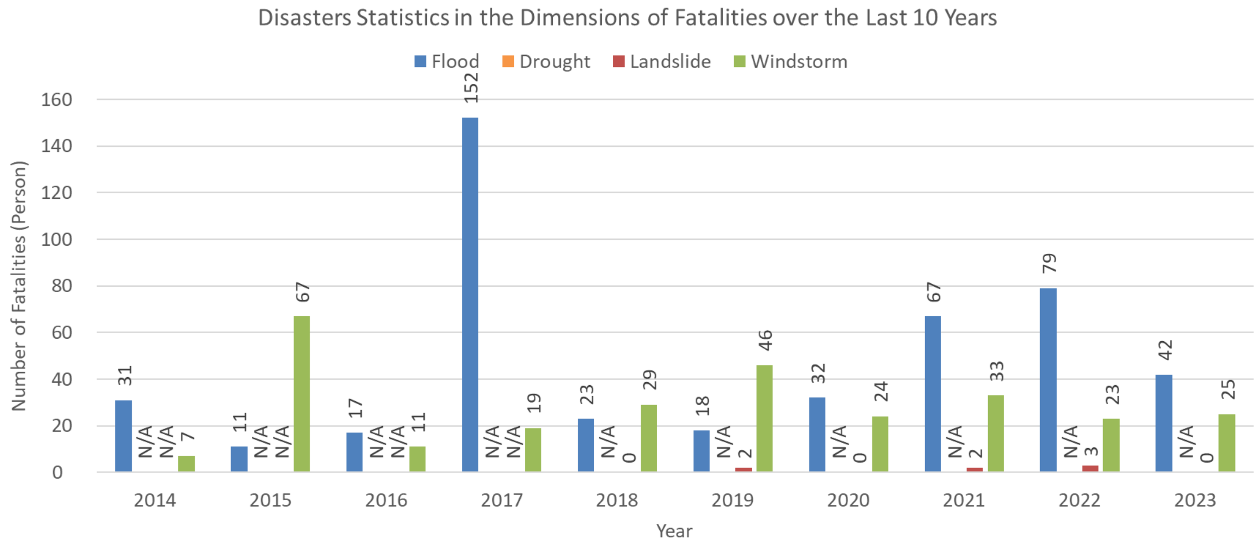


Figure 1-23: Number of fatalities of past disasters in Thailand (2014 – 2023) (DDPM, 2024a)

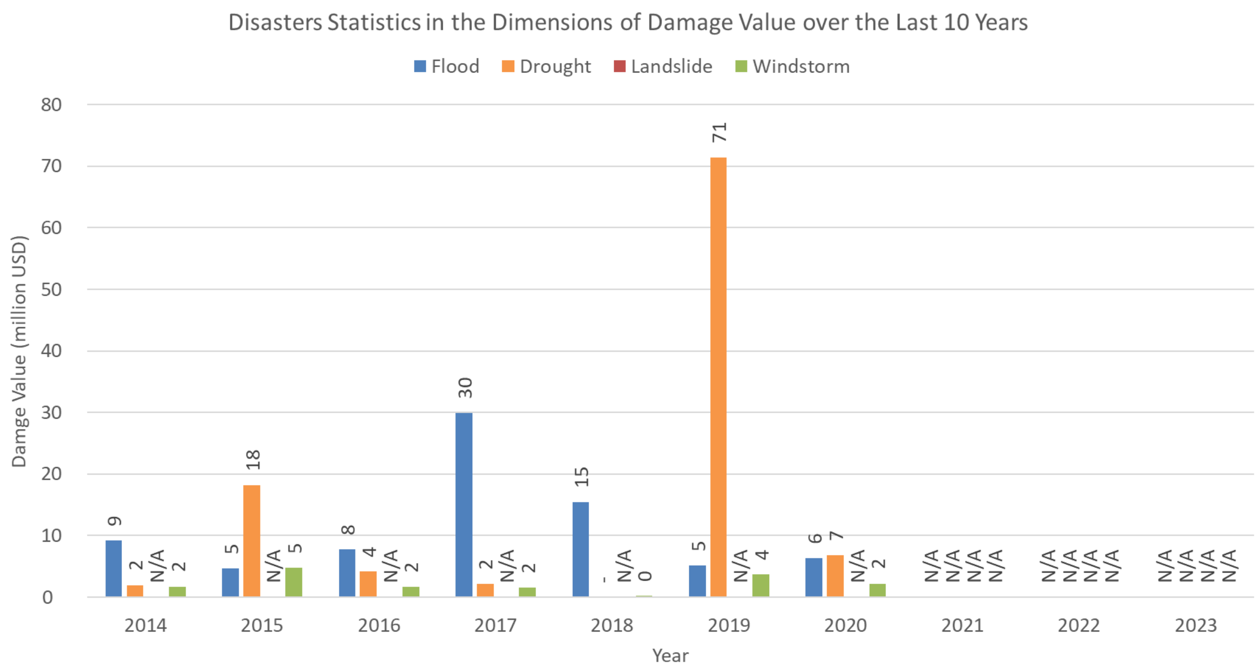


Figure 1-24: Damage value of past disasters in Thailand (2014 – 2023) (DDPM, 2024a)

Table 1-6: Past disasters in Thailand (2014 – 2023) ((DDPM, 2024a) and (DDPM, 2024d))

Disaster type	Number of deaths (People)	Number of affected (Households)	Damage value (USD, Millions)
Flood	472	8,131,694	78
Drought	N/A	5,875,403	105
Landslide*	7	1,936	N/A
Windstorm	284	1,195,318	16

Note: * Past data from 2019 – 2023

1.5.2.2 Risk Area in Thailand

Disaster risk areas in Thailand, such as floods, droughts and landslides, are identified using statistical data on recurring disaster-prone areas and vulnerable villages (2017–2023) from the Department of Disaster Prevention and Mitigation (DMPP), based on reports from Disaster Prevention and Mitigation Provincial Offices.

Windstorm risk areas have been analyzed by the DDPM. This analysis utilizes data from the Tambon Smart Team project, conducted by the Department of Local Administration (DLA) from 2011 to 2020, using the "4x4 Risk Matrix" method, based on risk management theory as described in Figure 1-25 and Table 1-7.

Risk = Likelihood x Impact

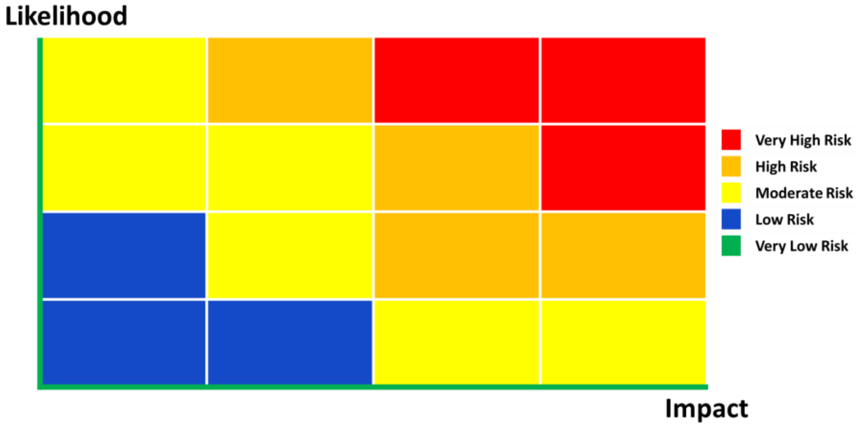


Figure 1-25: The "4x4 Risk Matrix" method (DDPM, 2022)

Table 1-7: Description of risk area assessment (DDPM, 2022)

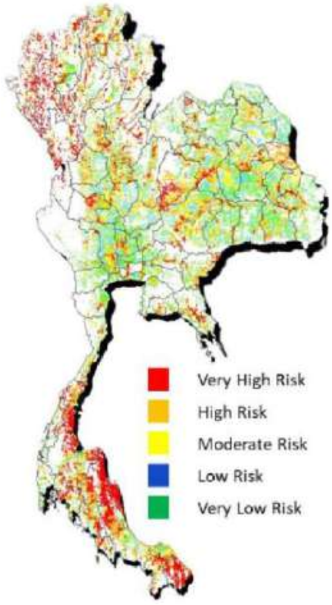
Risk Assessment	Descriptions
Very High Risk	Villages with both very high likelihood and very high impact.
High Risk	Villages with either very high likelihood and high impact, or high likelihood and very high impact.
Moderate Risk	Villages with very high likelihood and low impact, or low likelihood and high impact, or moderate likelihood and moderate impact.
Low Risk	Villages with low likelihood and low impact.
Very Low Risk	Villages with no history of disaster.

1) Flood Risk Area Analysis

The flood risk area has criteria based on measuring flood frequency (Table 1-8) and number of villages/communities affected by flooding as shown in Figure 1-26.

Table 1-8: Important criteria for measuring flood risk areas in Thailand

Flood Frequency	Descriptions
Very High Risk	Flooding occurs repeatedly in the same village 6 or more times over 7 years.
High Risk	Flooding occurs in the same village 4–5 times over 7 years.
Moderate Risk	Flooding occurs in the same village 3 times over 7 years.
Low Risk	Flooding occurs in the same village 2 times over 7 years.
Very Low Risk	Flooding occurs in the same village once over 7 years.
No Risk	No recorded history of flooding in the area.



Region	Very Low Risk		Low Risk		Moderate Risk		High Risk		Very High Risk	
Number of Villages/Communities Affected by Flooding, Categorized by Risk Level										
	Province	Village	Province	Village	Province	Village	Province	Village	Province	Village
Central	20	3,818	20	4,291	19	2,364	19	1,676	12	395
Eastern	7	883	7	639	7	571	7	615	7	253
Northeastern	20	8,727	20	7,999	20	5,267	18	5,203	16	1,189
Southern	13	999	14	1,284	14	1,142	14	2,230	14	3,360
Northern	15	2,426	15	2,393	15	2,346	15	3,162	15	2,591
Total	75	16,853	76	16,606	75	11,690	73	12,886	64	7,788

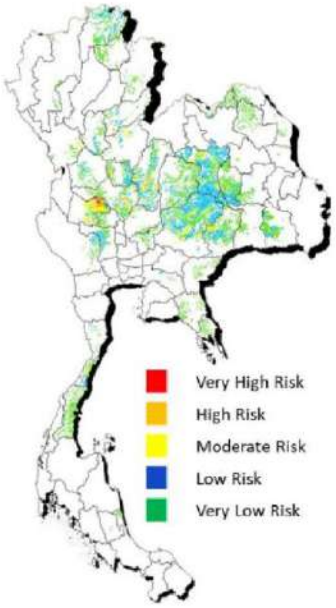
Figure 1-26: Flood risk areas in Thailand classified by risk level (DDPM, 2024c)

2) Drought Risk Area Analysis

The drought risk area has criteria based on measuring the frequency of emergency drought assistance announcements (Table 1-9) and number of villages/communities affected by drought as shown in Figure 1-27.

Table 1-9: Important criteria for measuring drought risk areas in Thailand

Drought Frequency	Descriptions
Very High Risk	Declared repeatedly in the same village 6 or more times within 7 years.
High Risk	Declared repeatedly in the same village 4–5 times over 7 years.
Moderate Risk	Declared repeatedly in the same village 3 times over 7 years.
Low Risk	Declared repeatedly in the same village 2 times over 7 years.
Very Low Risk	Declared repeatedly in the same village once over 7 years.
No Risk	No recorded history of drought emergency assistance announcements in the area.



Region	Very Low Risk		Low Risk		Moderate Risk		High Risk		Very High Risk	
	Province	Village	Province	Village	Province	Village	Province	Village	Province	Village
Central	8	1,361	7	530	4	437	3	157	1	14
Eastern	5	602	1	19	-	-	-	-	1	7
Northeastern	14	7,043	9	4,450	6	590	2	25	-	-
Southern	3	686	-	-	-	-	-	-	-	-
Northern	12	2,893	10	1,403	5	305	3	61	-	-
Total	**42**	**12,585**	**27**	**6,402**	**15**	**1,332**	**8**	**243**	**2**	**21**

Number of Villages/Communities Affected by Drought, Categorized by Risk Level

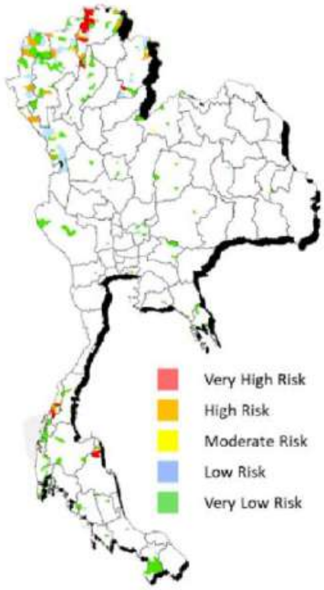
Figure 1-27: Drought risk areas in Thailand classified by risk level (DDPM, 2024b)

3) Landslide Risk Area Analysis

The landslide risk area has criteria based on measuring landslide frequency (Table 1-10) and number of districts/municipalities affected by landslide as shown in Figure 4-13.

Table 1-10: Important criteria for measuring landslide risk areas in Thailand

Landslide Frequency	Descriptions
Very High Risk	Landslide occurs repeatedly in the same district 6 or more times over 7 years.
High Risk	Landslide occurs in the same district 4–5 times over 7 years.
Moderate Risk	Landslide occurs in the same district 3 times over 7 years.
Low Risk	Landslide occurs in the same district 2 times over 7 years.
Very Low Risk	Landslide occurs in the same district once over 7 years.
No Risk	No recorded history of Landslide in the area.



Number of District/Municipality Affected by Landslide, Categorized by Risk Level										
Region	Very Low Risk		Low Risk		Moderate Risk		High Risk		Very High Risk	
	Province	District/ Municipality	Province	District/ Municipality	Province	District/ Municipality	Province	District/ Municipality	Province	District/ Municipality
Central	10	23	5	30	4	9	5	16	3	10
Eastern	5	10	-	-	-	-	-	-	-	-
Northeastern	7	14	2	2	1	1	-	-	-	-
Southern	12	44	1	1	3	5	3	5	2	8
Northern	9	56	7	30	4	9	5	16	3	10
Total	43	147	15	50	8	15	8	21	6	20

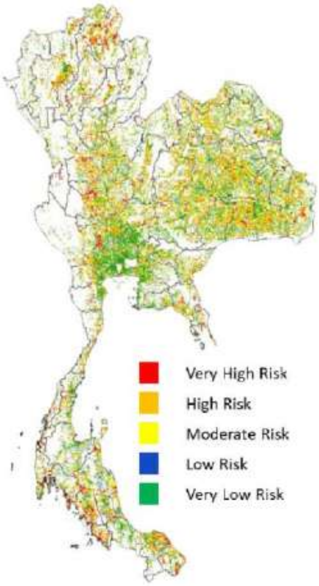
Figure 1-28: Landslide risk areas in Thailand classified by risk level (DDPM, 2024d)

4) Windstorm Risk Area Analysis

Windstorm Risk areas are calculated by using important information (Table 1-11) and number of villages/communities affected by windstorm as shown in Figure 1-29.

Table 1-11: Important information for analyzing windstorm risk areas in Thailand.

Information	Details
1. Likelihood of Windstorm Per Village	- Annual or more than once a year - Every 2 years - Every 3 years - Every 4-9 years - Every 10 years or more
2. Impact	- Total destruction of houses (requires rebuilding to be habitable). - Damage to roofs, walls, and building materials (can be repaired and still habitable). - Broken or fallen electric poles (causes power outages and inconvenience). - Fallen large trees (may pose a danger).



Region	Number of Villages/Communities Affected by Windstorm, Categorized by Risk Level									
	Very Low Risk		Low Risk		Moderate Risk		High Risk		Very High Risk	
	Province	Village	Province	Village	Province	Village	Province	Village	Province	Village
Central	20	8,859	20	485	20	3,585	20	2,898	18	793
Eastern	8	2,710	8	216	8	1,271	8	996	8	220
Northeastern	20	12,504	20	1,055	20	10,924	20	8,553	20	1,361
Southern	14	3,323	14	946	14	2,644	14	1,937	14	937
Northern	14	4,179	14	629	14	3,989	14	3,886	14	1,489
Total	76	31,575	20	485	76	22,413	76	18,270	74	4,800

Figure 1-29: Windstorm risk areas in Thailand classified by risk level (DDPM, 2022)

1.6 STATE OF NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT

Thailand's past development followed the 12th National Economic and Social Development Plan (2017-2021) with its core principles of sustainable development, sufficiency economy, and people centered development. The plan adhered to the 20-Year National Strategy Framework (2017-2036) and commitment to the Sustainable Development Goals (SDGs). The 13th National Economic and Social Development Plan (2023-2027) is going to be implemented. Its objective is to transform Thailand into a progressive society with a high-valued and sustainable economy. Five key targets are prioritized: 1) transforming the production structure toward innovation to enhance competition capacity in production and service sectors, and to respond to modern environmentally friendly technology development; 2) equipping Thai people with skills and capacities for adjusting to the modern world norms and market; 3) reducing poverty and inequality gaps by providing opportunities for business competition, enabling social mobility for vulnerable and underprivileged groups, and providing impartial and high-quality public service; 4) moving toward sustainable production and consumption aligning with the absorptive level of the ecosystem and mitigating climate change impacts by reaching carbon neutrality; 5) building Thailand's capacity to handle risk and change in the modern world context such as climate change impacts, pandemics, and cyber threats.

1.6.1 Economic Profile

The Thai economy grew by 2.5% in 2022, accelerating from 1.6% in 2021. The growth was driven mainly by the tourism recovery and continual improvement of domestic demand in both private consumption and investment. The headline inflation was at 6.1% and the current account registered a deficit of 3.4% of GDP (see Table 1-12).

In 2022, private consumption expenditures grew by 6.2%, improving from a 0.6% growth in 2021. Total changes of private investment grew by 4.7% due to an increase in machinery and equipment by 6.7% and a decrease in construction by 1.2%, compared to 2021.

Export value was recorded at 285.2 billion USD, an increase of 5.4% compared to 2021. Export items with decreased value included machinery & equipment, chemicals & petrochemical products, vehicle parts and accessories, passenger cars, pickups and trucks, computer parts and accessories, air conditioning machines, medicinal and surgical equipment, animal food, rice, rubber, and crustaceans. On the other hand, export items with increased value included parts of electrical appliances, integrated circuits and parts, rubber products, fish canned prepared or preserved, and beverages.

Import value stood at 271.6 billion USD, increasing by 14.0%, compared to 2021. Almost all the import value categories decreased. Import value of consumer goods decreased by 2.0%. Import value of raw materials and intermediate goods and capital goods contracted by 3.9% and 6.2%, respectively.

Agriculture, forestry, and fishing and construction sectors rebounded, while accommodation and food service activities, wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, and electricity, gas, steam and air conditioning supply sectors slightly increased. Nonetheless, the manufacturing sector decreased. The agricultural, forestry, and fishing sectors rebounded by 3.6% following the increase in major agricultural production. The expansion was supported by favorable weather conditions and sufficient water supply. The manufacturing sector contracted by 4.9% following the decline in production of the export-oriented industries (with export shares more than 60% of total production) and production of the domestic-oriented industries (NESDC, 2023a).

Table 1-12: Economic profile of Thailand during the 2021 – 2023 (NESDC, 2024)

	Actual Data		
	2021	2022	2023
GDP (at current prices: Bil. Baht)	16,188.6	17,378.0	17,922.0
GDP per capita (Baht per year)	231,986.1	248,788.6	255,879.5
GDP (at current prices: Bil. USD)	505.9	495.1	514.8
GDP per capita (USD per year)	7,249.60	7,094.1	7,349.9
GDP growth (CVM, %)	1.6	2.5	1.9
Investment (CVM, %)	3.1	2.3	1.2
Private (CVM, %)	2.9	4.7	3.2
Public (CVM, %)	3.5	-3.9	-4.6
Private consumption (CVM, %)	0.6	6.2	7.1
Government consumption (CVM, %)	3.7	0.1	-4.6
Export volume of goods & services (%)	11.1	6.1	2.1
Export value of goods (Bil. USD)	270.6	285.2	280.7
Growth rate (%)	19.2	5.4	-1.5
Growth rate (Volume, %)	15.5	1.2	-2.7
Import port volume of goods & services (%)	17.8	3.6	-2.3
Import value of goods (Bil. USD)	238.2	271.6	261.4
Growth rate (%)	27.7	14.0	-3.8
Growth rate (Volume, %)	17.9	1.2	-4.1
Trade balance (Bil. USD)	32.4	13.5	19.4
Current account balance (Bil. USD)	-10.3	-15.7	9.6
Current account to GDP (%)	-2.0	-3.2	1.9
Inflation (%)			
CPI	1.2	6.1	1.2
GDP deflator	1.8	4.8	1.2

Tourism Sector

In 2022, the majority of foreign tourists represented high purchasing power and a long length of stay at 16.2 days/trip, longer than the 10.3 days/trip in the pre-COVID period (see Figure 1-30). Most of them were short-haul tourists from East Asia countries, such as Malaysia and Singapore, along with South Asia countries, such as India (the share of foreign tourist volume doubled from pre-COVID levels). The average expenditure of foreign tourists in 2022 was about 2,058 USD/person/trip (NESDC, 2023a).

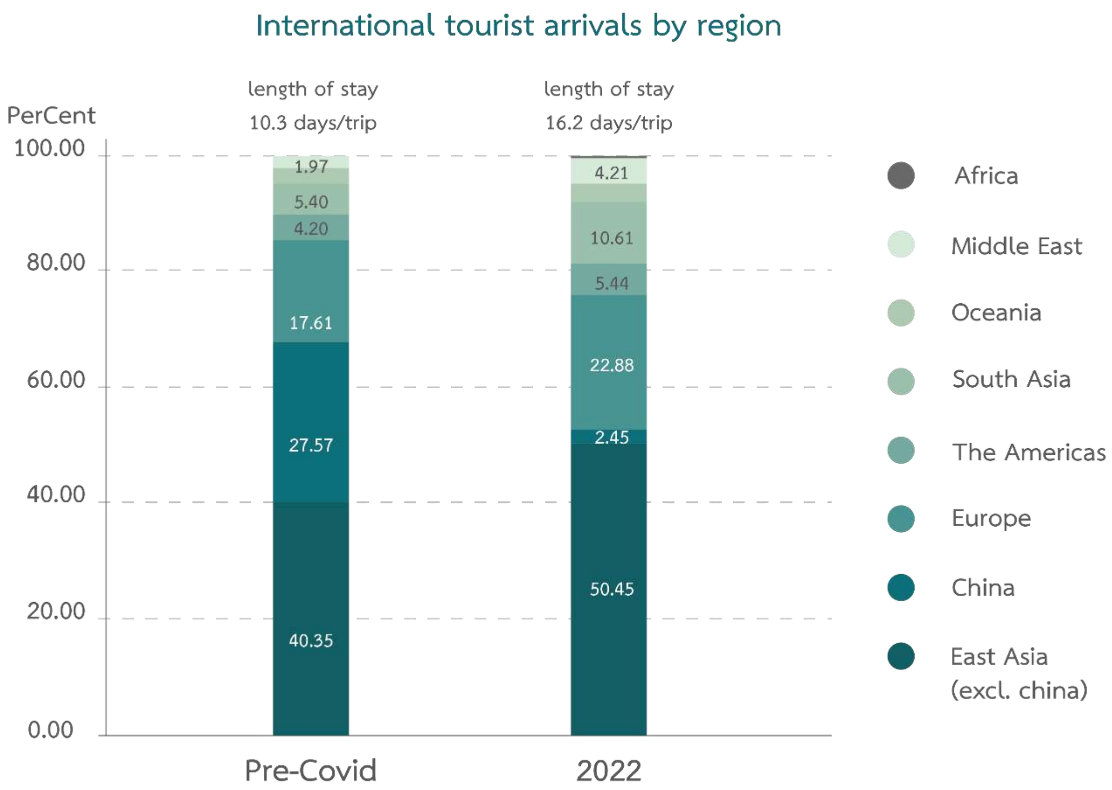


Figure 1-30: International tourist arrivals to Thailand by region (NESDC, 2023a)

1.6.2 Social Profile

Three key indicators included in consideration of the social situation of Thailand are employment, household debt, and health and illness. Key social situations in the outlook of 2022 are elaborated as follows: The labor situation has improved. The unemployment rate declined to 1.15% in the fourth quarter, while the unemployment rate in 2022 was 1.32% (see Table 1-13). Household debt (third quarter of 2022) increased following the economic recovery, but the credit quality remained stable.

Labor situation

In terms of an overview of 2022, the labor situation improved. Employment and working hours increased to levels comparable to the pre-COVID-19 period. A total of 39.2 million people were employed, a 1.0% increase. Employment in the non-agricultural sector expanded by 2.0% as the economy improved following the previous year's surge in tourism and exports. On the other hand, employment in the agriculture sector has decreased by 1.2% since July 2022 as a result of the floods and the movement to industries that have recovered well.

Many countries across the world have prioritized upskilling following vast changes in technology to be in line with future demand. Likewise, Thailand has introduced policies to transform its economic structure into an innovation-based economy through the targeted industries. This will be a key mechanism in driving the new growth engine, along with continuously developing and enhancing labor skills. Receiving appropriate wages not only leads to better wellbeing of workers, but also helps reduce poverty and boost productivity. For Thailand, the wage setting involves various methods as follows: 1) Minimum wage setting sufficient to live a decent life and appropriate for the business's ability, 2) Wage-based wage standard providing semi-skilled and skilled workers reasonable wages, and 3) Market mechanisms for workers with medium skill and above through direct negotiation with employers.

Table 1-13: Social profile of Thailand during the 2021 – 2023 ((NESDC, 2022) and (NESDC, 2023b))

Components	Year	
	2021	2022
1. Employment		
Workforce (Thousands)	39,812.5	39,903.3
Employed persons (Thousands)	38,829.0	39,221.1
Unemployed persons (Thousands)	781.9	527.0
Unemployment rate (%)	2.0	1.3
Underemployed persons (Thousands)	601.8	273.3
2. Household debt		
Household debt value (Trillion Baht)	14.6	15.9
Ratio to GDP (%)	90.1	91.4
NPL (Billion Baht)	143.7	140.4
%NPL to total loan	2.7	2.6
3. Health and illness		
Number of patients under disease surveillance		
Measles	227	249
Meningococcal fever	13	18
Encephalitis	663	923
Cholera	1	5
Hand, foot and mouth	19,008	98,982
Dysentery	1,203	1,572
Pneumonia	153,277	231,105
Leptospirosis	1,150	3,601
Dengue fever	9,956	45,145
Influenza	10,698	79,374
Rabies	3	3

Poverty and inequality situation

Household debt increased in 2022, while credit quality remained stable. The number of debtors who were in good standing but became bad debts as a result of COVID-19's impact is increasing. Household debt was 15.90 trillion Baht in 2022, a 3.7% increase compared to the previous year. This was due to the economic recovery and improving labor market conditions. Meanwhile, the household debt-to-GDP ratio was 91.4%, an increase from the previous year. The credit quality of commercial banks remained stable. Non-performing consumer debt accounted for 2.62% of total loans in the year 2022. Household debt decelerated and the household debt repayment ability has decreased.

Personal income tax is a crucial source of income and plays an important role in allocating resources to people in society more equitably. A more efficient and equitable allocation will ultimately lead to the reduction of inequality. In 2021, the total revenue of the government was 2.8 trillion baht, with tax revenues accounting for 88.5% of all revenues. Personal income tax collection in 2021 accounted for 13.2% of all tax revenues, with the value of 337,779 million Baht. In terms of source of income, the proportion of personal income tax to total tax revenue collected during 2013 - 2021 is in the range of 12.2 - 13.7% or about 2.09% of GDP, which is relatively low compared to the Organization for Economic Co-operation and Development (OECD) countries with an average of 24.1%. Personal income tax has contributed to reducing inequality despite some limitations as the progressivity of income tax systems is less than many countries.

Rice is an agricultural commodity that contributes in excess of 100 billion baht to Thailand's annual export income. However, farmers frequently face an unpredictable income, resulting in impoverished conditions. Specifically, from 2014-2023, the government consistently provided substantial support, averaging 5.4 trillion baht annually. This is attributed to issues across various domains: fluctuations of rice price hinder effective planning of production, increased fertilizer cost and low rice yields per area. The aforementioned issues lead to recommendations aimed at enhancing rice cultivation productivity and improving the quality of life for farmers as follows: 1) establishing mechanisms to strengthen farmers through group collaboration and the creation of new-generation farmers; 2) promoting continuous research and development of rice varieties, and enhancing the efficiency of producing high-quality rice seeds for cultivation; 3) promoting the reduction of chemical fertilizer usage, focusing on soil maintenance or the use of lower-priced organic fertilizers; 4) promoting technology adoption by creating a startup-friendly environment that fosters market competition, leading to reduced technology costs. Showcasing examples of successful technology adoption and providing support for funding sources and knowledge transfer to farmers; 5) providing farmers with knowledge on crop cultivation techniques suitable for their specific geographical conditions; 6) developing agricultural insurance systems to protect against agricultural losses caused by natural disasters and elevating them as tools to support the agricultural production process; and 7) considering the replacement of rice cultivation with other high-value crops that align with agricultural land management (Zoning by Agri-Map) and social conditions in each area.

In consideration of factors affecting the quality of education and quality of life for Thai children, Thailand's education system is signaling a crisis, reflected in the educational indicators at both national and international levels. The Programme for International Student Assessment (PISA) assesses the competencies of 15-year-old students worldwide in three areas: reading, mathematics, and science; the average scores for Thai students in all three areas are lower than the OECD average. Furthermore, economically disadvantaged children have lower average scores than children from richer households. Therefore, to address structural issues and reduce educational disparities, as well as create a conducive learning environment, all stakeholders must collaborate to address the following issues: 1) Schools should receive a fair allocation of educational resources; 2) The government needs to enhance access to quality education that aligns with students' needs and create support mechanisms for children who drop out of school; 3) Creating an environment that supports learning and is safe entails establishing areas for feedback, encouraging participation, and fostering a trusting and creative atmosphere.; 4) Supporting families' roles in caring for children together with schools, by providing communication space between parents, children, and teachers to discuss learning, needs, behaviors, and potential.

Health situation

Disease surveillance showed increases in some diseases, especially influenza throughout the year 2022. While illness from non-communicable diseases (NCDs) decreased in 2021, the rates of depression and suicide remained high. Illness from surveilled diseases increased by 308.4% in the fourth quarter of 2022, with pneumonia, influenza, and dengue fever being the top three causes. From 2021 to 2022, the number of patients with surveilled diseases increased by 134.9%, with pneumonia accounting for the majority of the increase. The prevalence of five NCDs has decreased. However, the number of illnesses caused by air pollution reached 10.3 million in 2022. Furthermore, mental health issues are a significant concern. Patients suffering from depression increased from 355,537 in 2020 to 358,267 in 2021, with a suicide rate of 7.38 per 100,000 people. However, the issues that must be prioritized in the next phase include preventing the spread of COVID-19 to allow fully opening for tourism, promoting healthy behaviors, and finding sustainable solutions to air pollution.

1.6.3 Gender equality

Thailand has continuously improved and developed legislation to promote women's rights and gender equality. Laws exist to protect women from domestic violence and from sexual violations and harassment in the workplace; as well as to combat and suppress human trafficking while also taking care of and rehabilitating victims of human trafficking, who are mostly women and children. Thailand promulgated the 2015 Gender Equality Act, which became effective on 9 September 2015, to protect everyone from gender-based discrimination (Government Ministry, 2015). Moreover, Thailand enacted marriage equality legislation that supports same-sex marriage by promulgating the Marriage Equality Act on 18 June 2024.

From the 2022 Global Gender Gap rankings and the scores for all 146 countries, Thailand's economy was ranked 79th. Moreover, at the subindex level, Thailand was ranked 15th (with 79.5% of its gender gap) in terms of Economic Participation and Opportunity, 92nd (with 97.9% of its gender gap) in terms of Educational Attainment, 37th (with 97.8% of its gender gap) in terms of Health and Survival and 130th (with 8.4% of its gender gap) in terms of Political Empowerment.

Furthermore, over half of the countries in East Asia and the Pacific, 10 out of the 19, improved their gender parity scores on Economic Participation and Opportunity. Thailand was ranked 8th in gender parity (see Table 1-14). The region has also seen an increase in the share of women in senior positions (legislators, senior officials and managers) in 10 of the 19 countries, including Vanuatu, Mongolia, Cambodia, Thailand and Australia. The Health and Survival subindex has a slightly lower level of parity across the region, at 95.2%. Only five countries in this region have achieved gender parity in healthy life expectancy: Mongolia, Viet Nam, Thailand, Myanmar and Philippines (WEF, 2022).

Table 1-14: The Global Gender Gap Index rankings by East Asia and the Pacific, 2022 (WEF, 2022)

Country	Rank		Score
	Regional	Global	
New Zealand	1	4	0.841
Philippines	2	19	0.783
Australia	3	43	0.738
Singapore	4	49	0.734
Lao PDR	5	53	0.733
Timor-Leste	6	56	0.730
Mongolia	7	70	0.715
Thailand	8	79	0.709
Vietnam	9	83	0.705
Indonesia	10	92	0.697
Cambodia	11	98	0.690
Republic of Korea	12	99	0.689
China	13	102	0.682
Malaysia	14	103	0.681
Brunei Darussalam	15	104	0.680
Myanmar	16	106	0.677
Fiji	17	107	0.676
Vanuatu	18	111	0.670
Japan	19	116	0.650

1.7 INSTITUTIONAL ARRANGEMENT

1.7.1 National Committee on Climate Change Policy (NCCC)

Thailand's National Committee on Climate Change Policy (NCCC) is chaired by the Prime Minister and has members from both the public and private sectors, including experts from relevant agencies (see Figure 1-31). The NCCC has the mandate to define national climate policies and establish guidelines and mechanisms for international collaboration regarding conventions and protocols on climate change, including supporting and evaluating relevant domestic agencies to be in accordance with the national established policies and plans.

The NCCC is composed of eight subcommittees: 1) Subcommittee on Climate Change Policy and Planning Integration, 2) Subcommittee on Climate Change Knowledge and Database, 3) Subcommittee on Climate Change Negotiation and International Cooperation, 4) Subcommittee on Public Relations and Actions for Climate Empowerment 5) Subcommittee on Climate Law, 6) Subcommittee on Thailand Climate Action Conference 7) Subcommittee on the Mobilization of GHG Mitigation with Carbon Sequestration in LULUCF Sector and 8) Subcommittee on the Mobilization of GHG Mitigation with CCUS Technology Implication.

The Subcommittee on Climate Change Policy and Planning Integration is responsible for providing input on policy integration, strategy, and planning linked with climate mitigation and adaptation; providing suggestions on mechanisms and measures, such legal regulations, and financial measures; and pushing forward an integrated budget allocation system on climate change. Recently, three working groups were assembled within the subcommittee: 1) Working Group on GHG Mitigation Policy and Planning to provide comments on and recommendations for making and integrating mitigation policy, strategy, and plans, aligning with national targets, and mobilizing and advancing GHG mitigation actions to achieve the targets; 2) Working Group on National Climate Change Adaptation Implementation Integration to provide comments on and recommendations for forming national adaptation plan and supporting the integration of the adaptation plan into sectoral plans in all areas; 3) Ad-Hoc Working Group on REDD-Plus to form a strategy, action plan, and implementation measures on climate actions in the forest sector and REDD-Plus and to establish mitigation and carbon storage targets for the forest sector in Thailand.

The Subcommittee on Climate Change Knowledge and Database is responsible for providing comments on the country report under the agreement of UNFCCC; supporting the development of the GHG inventory; providing suggestions on the development of databases and climate change knowledge in the areas of mitigation, adaptation, and Measurement, Reporting and Verification (MRV) systems. Recently, two working groups were assembled within the subcommittee: 1) Working Group on GHG Inventory and Mitigation Measures to provide recommendations on the data used for the preparation of GHG inventory in each sector, MRV direction, and assessment of GHG reduction from the mitigation measures; 2) Working Group on Climate Change Data and Modeling to build networks for collecting, sharing, processing, and analyzing data and mobilizing and coordinating the operation relating to climate change data and modeling.

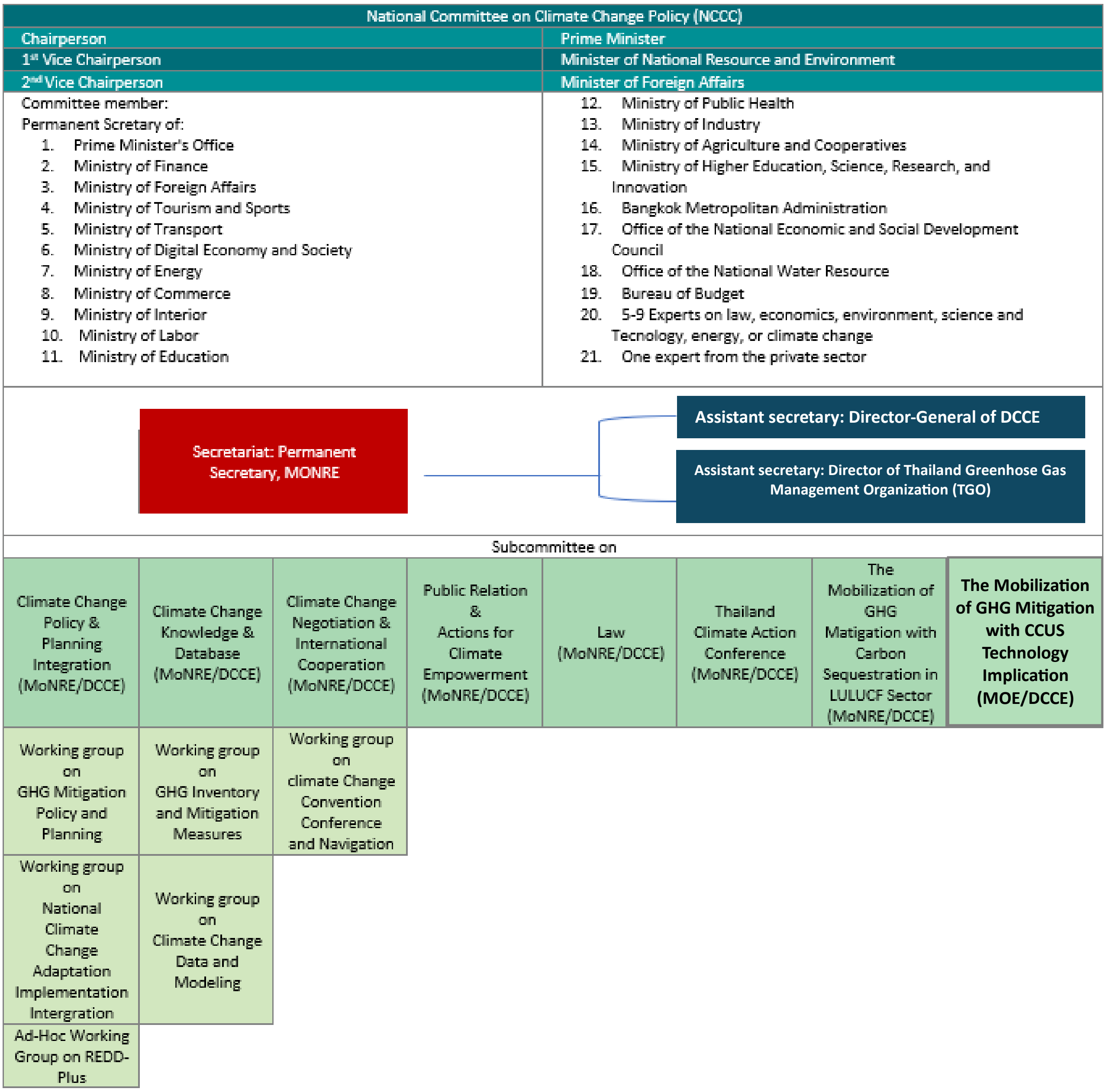


Figure 1-31: Structure of the National Committee on Climate Change Policy

The Subcommittee on Climate Change Negotiation and International Cooperation is responsible for providing recommendations on Thailand's positions for negotiations on climate change under multilateral agreements and other international frameworks; preparing and developing knowledge and data concerning international negotiations on climate change; providing guidance in international aspects of climate change implementation and the composition of Thailand's delegation for international negotiation on climate change. The Working Group on Climate Change Convention Conference and Negotiation was recently assembled to analyze, suggest, and prepare detailed information for the negotiation and conference under UNFCCC.

The Subcommittee on Public Relations and Actions for Climate Empowerment is responsible for publicizing news and knowledge on the causes, impacts, and solutions related to climate change under the Paris Agreement, Thailand's Nationally Determined Contributions (NDC) targets, and the SDGs. This committee also promotes and supports activities related to climate change by conducting training, raising awareness, and implementing capacity building across all sectors.

The Subcommittee on Law is responsible for providing comments on policies for the development, improvement, cancellation, or amendment of laws related to climate change according to the NCCC; arranging and proposing draft laws, rules, regulations, or notifications; provide legal opinions on tackling issues related to climate change; and finally, to provide advice on the enforcement of laws related to national climate change.

The Subcommittee on Thailand Climate Action Conference is responsible for setting direction and objectives of the conference, leading preparation in accordance with its objectives, approving and supporting activities of the conference and reporting results of the Thailand climate action conference to the NCCC. The subcommittee also has the authority to assign relevant agencies or invite representatives from both government and private sectors to provide information and comments, as appropriate.

The Subcommittee on the Mobilization of GHG Mitigation with Carbon Sequestration in LULUCF Sector is responsible for providing suggestions and recommendations on guidelines, mechanisms, and measures supporting reforestation and conservation and expansion of green areas for public and private stakeholders to push forward long-term strategy for GHG removal. The subcommittee has the Minister of Natural Resources and Environment as the president and consists of representatives from public and private sectors such as the Office of the National Land Policy Board (ONLB), Land Development Department (LDD), Department of Lands, Royal Forest Department (RFD), Department of Natural Parks, Wildlife and Plant Conservation (DNP), Thai Banker's Association (TBA), and Bank for Agriculture and Agriculture Cooperatives (BAAC).

The Subcommittee on the Mobilization of GHG Mitigation with CCUS Technology is responsible for providing suggestions and recommendations on GHG mitigating capacity of Carbon Capture and Storage technology and carbon storage and utilization. The subcommittee also has the authority to suggest mechanisms or measures (e.g., legal, economic, and other related measures) for incentivizing, developing, and applying such technology. The subcommittee has the Minister of Energy as the president and consists of representatives from public and private sectors such as the Department of Alternative Energy Development and Efficiency (DEDE), Department of Mineral Resources (DMR), Department of Mineral Fuels (DMF), Department of Industrial (DOI).

1.7.2 Institutional Arrangements of National Greenhouse Gas Inventory

Calculations of the national GHG inventory to report in the Thailand's First Biennial Transparency Report (BTR1) have been made in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The key components in estimating GHG emissions are activity data and emission factors. Activity data are obtained from the collaboration between DCCE and the lead agencies of the following five sectors.

1) Energy - led by the Energy Policy and Planning Office (EPPO) and the Office of Transport and Traffic Policy and Planning (OTP)
2) IPPU - led by the Department of Industrial Works (DIW)
3) Agriculture - led by the Office of Agricultural Economics (OAE)

4) LULUCF - led by the Department of National Parks, Wildlife and Plant Conservation (DNP)

5) Waste - led by the Pollution Control Department (PCD).

After these lead agencies have collected activity data according to DCCE required template from relevant agencies responsible for data collection (e.g., agencies under their supervision, local government, and the private sector), The GHG emission is calculated by the Thailand Greenhouse Gas Emission Inventory System (TGEIS). Results are interpreted into graphs and tables according to the reporting format laid out by UNFCCC. Then, results from TGEIS are submitted to five working groups, comprising appointed representatives of the five sectors outlined above. Each working group then reviews the methodology of the GHG emission estimation as part of quality control (QC) to ensure that GHG emission estimates for their sectors are valid, accurate, and complete. Following this, the GHG inventories of the five sectors are submitted to the Climate Change Knowledge and Database Subcommittee for verification.

Finally, as the Secretariat of the NCCC, DCCE will submit the final GHG inventories as part of the BUR to the NCCC for approval before submission to UNFCCC. For a complete list of the sub-sectoral support agencies under each leading sector (see Figure 1-32). The lead agencies and their responsibility in reporting data activity are as follows:

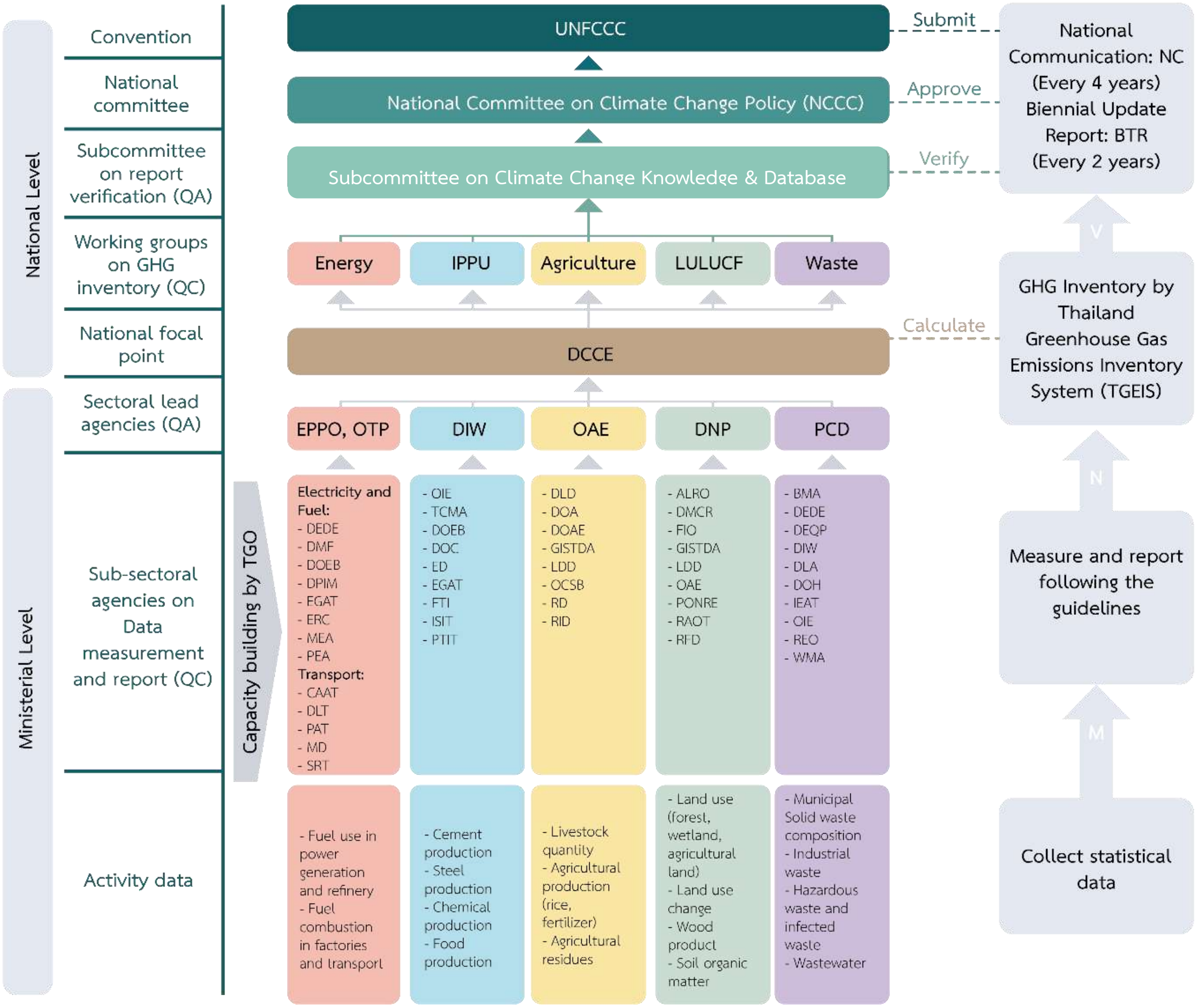
Energy: EPPO and OTP are the two leading agencies responsible for gathering the data from relevant agencies within the Ministry of Energy, the Ministry of Transport, and others. The activity data used for GHG emissions calculations are derived from fossil fuel/electricity consumption used in different activities.

Industrial Processes and Product Use (IPPU): DIW is the lead agency responsible for gathering the data from relevant agencies within the Ministry of Industry and others. The activity data used for GHG emissions calculations are each industry group's production volume, import volume, and export volume.

Agriculture: OAE is the lead agency responsible for gathering the data from relevant agencies within the Ministry of Agriculture and Cooperatives and others. The activity data used for GHG emissions calculations are derived from livestock farming, rice cultivation, agricultural soils, field burning, and the open burning of agricultural residues.

Land Use, Land-Use Change, and Forestry (LULUCF): DNP is the lead agency responsible for gathering the data from relevant agencies within the Ministry of Natural Resources and Environment (MONRE) and others. The activity data used for GHG emissions calculations are derived from land use, land-use change, and wood products.

Waste: PCD is the lead agency responsible for gathering the data from relevant agencies within the MONRE and others. The activity data used for GHG emissions calculations are derived from sources of waste, waste production rate, waste composition, and wastewater volume, including Emission Factors.



FIO	Agricultural Land Reform Office
ALRO	Bangkok Metropolitan Administration
BMA	The Civil Aviation Authority of Thailand
CAAT	Department of Alternative Energy Development and Efficiency
DCCE	Department of Climate Change and Environment
DEDE	Department of Environmental Quality Promotion
DEQP	Department of Industrial Works
DIW	Department of Livestock Development
DLD	Department of Local Administration
DLA	Department of Land Transport
DLT	Department of Marine and Coastal Resources
DMCR	Department of Mineral Fuels
DMF	Department of National Parks, Wildlife and Plant Conservation
DNP	Department of Agriculture
DOA	Department of Customs
DOC	Department of Agricultural Extension
DOAE	Department of Energy Business
DOEB	Department of Health
DOH	The Excise Department
ED	Electricity Generating Authority of Thailand
EGAT	Energy Policy and Planning Office
EPPO	Energy Regulatory Commission
ERC	Forest Industry Organization
FTI	The Federation of Thai Industries
GISTDA	Geo-Informatics and Space Technology Development Agency
ISIT	Iron and Steel Institute of Thailand
LDD	Land Development Department
MD	Marine Department
MEA	Metropolitan Electricity Authority
OAE	Office of Agricultural Economics
OCSB	Office of the Cane and Sugar Board
OIE	The Office of Industrial Economics
OTP	The Office of Transport and Traffic Policy and Planning
PAT	Port Authority of Thailand
PCD	Pollution Control Department
PEA	Provincial Electricity Authority
PONRE	Provincial Offices of Natural Resources and Environment
PTIT	Petroleum Institute of Thailand
RAOT	Rubber Authority of Thailand
RD	Rice Department
REO	Regional Environment Office
RID	Royal Irrigation Department
RFD	Royal Forest Department
SRT	State Railway of Thailand
TCMA	Thai Cement Manufacturers Association
WMA	Wastewater Management Authority

Figure 1-32: Structure of Thailand's Greenhouse Gas Inventory process

1.7.3 Institutional Arrangements and Legal Framework on Adaptation

1.7.3.1 Institutional Arrangements on Adaptation

Thailand's institutional arrangement for its national adaptation policy is shown in Figure 1-33. The National Committee on Climate Change (NCCC), chaired by the Prime Minister, defines policies, establishes guidelines, and oversees international collaboration. The Subcommittee on Climate Change Policy and Planning Integration provides expert guidance on integrating mitigation and adaptation into national strategies, recommends legal and financial measures, and advocates for coordinated budget allocation. The Working Group on National Climate Change Adaptation Implementation Integration develops the NAP, guides research and policy, integrates the NAP into sectoral and provincial plans, drives implementation, monitors and evaluates adaptation measures, and facilitates information sharing.

The DCCE collaborates with leading agencies in water resources management, agriculture and food security, tourism, public health, natural resources management, and human settlements and security for adaptation implementation. At the provincial level, working groups develop GHG emission data, mitigation plans, and risk profiles with funding from Thailand's Environmental Fund to ensure effective top-down and bottom-up communication and implementation of adaptation measures.

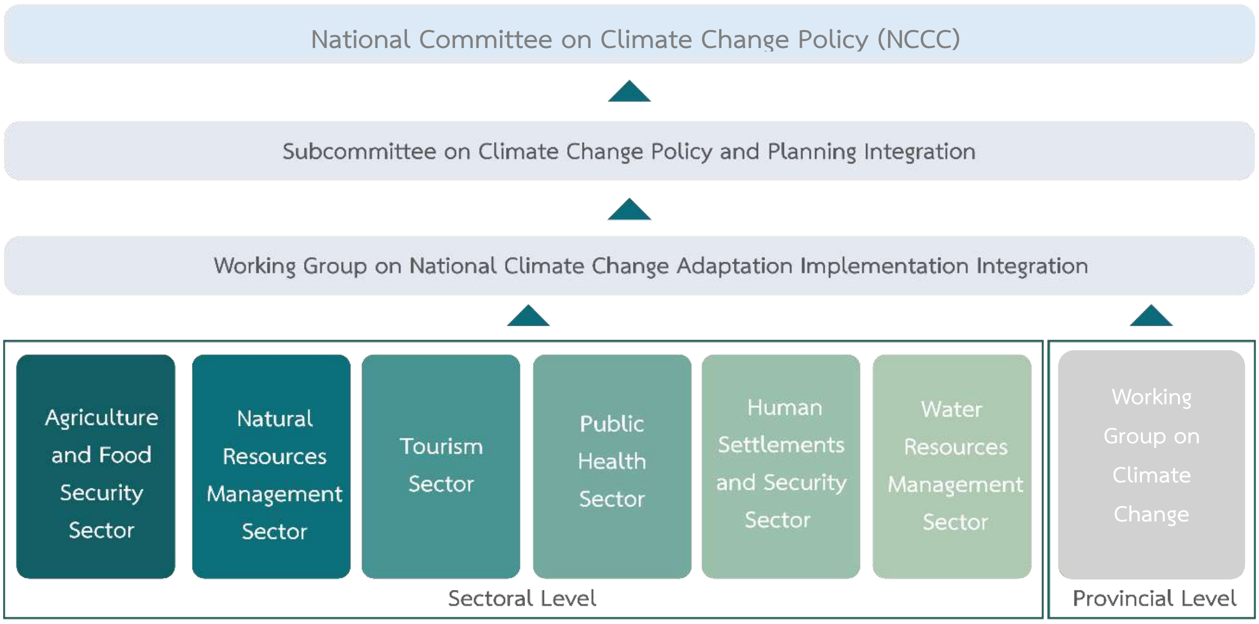


Figure 1-33: Institutional arrangement for climate change adaptation in Thailand (DCCE, 2023)

1.7.3.2 International Environmental Agreements

Thailand has signed and ratified several international environmental agreements, reflecting the country's commitment to environmental protection and sustainable development. Some of the key agreements and objectives are shown in Table 1-15.

Table 1-15: Ratification of Thailand in international environmental agreements

Agreement	Date Signed	Date Ratified	Objective
United Nations Framework Convention on Climate Change (UNFCCC)	12 June 1992	28 December 1994	Stabilize greenhouse gas (GHG) concentrations to prevent dangerous anthropogenic interference with the climate system.
Kyoto Protocol	2 February 1999	28 August 2002	Commit industrialized countries to reduce GHG emissions.
Paris Agreement	22 April 2016	21 September 2016	Strengthen the global response to the threat of climate change by keeping global temperature rise well below 2°C.
Convention on Biological Diversity (CBD)	12 June 1992	29 January 2004	Conserve biological diversity, ensure sustainable use, and share the benefits of genetic resources.
Ramsar Convention on Wetlands	5 July 1998	13 September 1998	Conserve and sustainably use wetlands through local and national actions and international cooperation.
Vienna Convention for the Protection of the Ozone Layer	22 March 1985	7 October 1989	Protect human health and the environment against the adverse effects of ozone layer depletion.
Montreal Protocol on Substances that Deplete the Ozone Layer	16 September 1987	7 October 1989	Phase out the production and consumption of ozone-depleting substances.

1.7.3.3 National Strategies / Plans / Policies

Thailand submitted its 2nd updated Nationally Determined Contributions and revised Thailand's Long-term Low Greenhouse Gas Emission Development Strategy (LT-LEDS) to UNFCCC in 2022, which results in strengthened emission reduction targets by 2030 (see Table 1-16).

The Thailand's LT-LEDS emphasizes integrating adaptation into its low-carbon development framework. This strategy focuses on enhancing resilience in sectors vulnerable to climate impacts, related to water resources management, agriculture and food security, tourism, public health, natural resources management, and human settlements and security. Key priorities include implementing sustainable land and water management practices, strengthening adaptive capacity in communities, and promoting innovation in climate-resilient technologies. Through these efforts, Thailand aims to balance mitigation and adaptation objectives, ensuring that low-carbon development also supports the nation's overall resilience to climate change.

Furthermore, Thailand also developed the Thailand's National Adaptation Plan (NAP), which serves as Thailand's primary framework for climate adaptation. It aims to enhance resilience across key sectors by integrating adaptation measures into national and local development plans. It also coordinates and guides the implementation of climate adaptation strategies. This process involves multiple stakeholders for a comprehensive response. The NAP was developed by analyzing sector-specific risks using downscaled global climate models under the IPCC's Special Report on Emission Scenarios (SRES) A1B scenario. It was refined through consultations with government, private sectors, academia, and non-governmental organizations (NGOs) using a participatory approach.

Thailand's key international commitments influence the development of the NAP by ensuring alignment with global standards and climate goals through participation in the UNFCCC and the Paris Agreement. Participation in these agreements enhances resilience and secures international support and financing. Additionally, the NAP incorporates Sustainable Development Goals, particularly Goal 13 (Climate Action), to further promote resilience and sustainable development.

The NAP aligns with key national policies, including the 20-year National Strategy (2018-2037), the National Climate Change Master Plan (2015-2050), and the Policy and Plan for Enhancement and Conservation of National Environmental Quality (2017-2037). The 20-year National Strategy aims for sustainable development through resilience, growth, well-being, and protection. It emphasizes integrating adaptation measures and improving disaster risk management. The Climate Change Master Plan guides adaptation into planning and budget allocation and raises awareness across sectors. The Policy and Plan for Enhancement and Conservation of National Environmental Quality promotes sustainable development, eco-friendly growth, efficient resource use, and sector partnerships for managing natural resources.

Table 1-16: Details of Strategies / Plans / Policies related to adaptation

Strategies / Plans / Policies	Adaptation Focus
1st Level Plan	
20-Year National Strategy (2018 - 2037)	The strategy related to climate change is addressed in Strategy 5, which focuses on promoting growth with a quality of life that is environmentally friendly. It emphasizes adaptation measures to reduce losses and damages from natural disasters and the impacts of climate change. The strategy also targets climate-friendly investments in developing infrastructure for both the public and private sectors, and the development of systems to cope with and adapt to emerging and re-emerging diseases resulting from climate change.

Table 1-16: Details of Strategies / Plans / Policies related to adaptation (Cont'd)

Strategies / Plans / Policies	Adaptation Focus
2nd Level Plans	
Master plan under national strategy (2023 - 2037)	The plan legally binds all relevant government agencies to implement it in an integrated manner. Additionally, the annual budget allocation must align with the National Strategy, which includes climate change issues, to achieve the specified goals in a concrete and measurable way.
13th National Economic and Social Development Plan (2023 - 2027)	The plan focuses on enhancing development mechanisms to be more effective and aligned with current conditions. This includes both legal frameworks and committee-based working mechanisms, as well as increasing the role of knowledge, technology, innovation, and creativity as core tools to drive development across all sectors.
National Security Policy and Plan (2023 - 2027)	The plan addresses climate change as a national security threat, focusing on protecting critical infrastructure, ensuring food and water security, and managing migration and displacement caused by climate impacts. It also emphasizes the importance of regional cooperation in climate adaptation.
Reform plan	The national reform plan on natural resources and the environment, related to climate change, focuses on increasing green spaces in urban and community areas, researching forest and wildlife resources, managing seasonal flooding, developing a national biodiversity database, advancing climate change legislation, analyzing impacts and risks of climate change in investment projects, establishing a GHG emissions and area-based risk database, creating economic incentives to support GHG reduction, and promoting behavioral changes among the public to sustainably address climate change issues.
3rd level plans	
Policy and Plan for Enhancement and Conservation of National Environmental Quality (2017 – 2037)	The plan is a long-term policy framework for managing the country's natural resources and environment. The key policy related to climate adaptation is Policy 2, which focuses on fostering environmentally friendly growth for prosperity and sustainability. It includes sub-policies aimed at building resilience to climate change and promoting low-carbon development, as well as preparing for and adapting to climate change and natural disasters.
Climate Change Master Plan 2015 - 2050	The master plan establishes a comprehensive framework for climate adaptation, focusing on enhancing resilience in key sectors such as agriculture, water management, tourism, natural resource management, human settlements, and public health. It aims to raise awareness about the importance of climate issues and foster a shared understanding among government agencies and relevant organizations to drive integrated climate change solutions without operational overlap. Additionally, it provides a framework for budget management agencies to allocate resources effectively, leading to tangible progress in addressing climate change challenges.

Table 1-16: Details of Strategies / Plans / Policies related to adaptation (Cont'd)

Strategies / Plans / Policies	Adaptation Focus
Bio-Circular-Green Economy (Bio-Circular-Green Economy: BCG) Model Action Plan	The Thai Government has promoted the development of the Bio-Economy, Circular Economy, and Green Economy to advance sustainability by leveraging Thailand's biological and cultural diversity. The approach closely aligns with climate adaptation strategies by promoting sustainable practices that enhance resilience to climate change. It encourages the use of biological resources and innovative technologies to develop adaptive agricultural systems, improve water management, and support sustainable energy solutions. By integrating circular economy principles, it aims to reduce waste and increase resource efficiency, which is crucial for adapting to changing environmental conditions. The green economy aspect focuses on reducing carbon footprints and fostering environmental conservation, which collectively contribute to building a climate-resilient economy in Thailand.

1.7.3.4 Legal and Policy Frameworks and Regulations

Climate Change Bill

The Climate Change Bill, formulated by the Department of Climate Change and Environment, provides a legal framework for Thailand's adaptation strategy, detailing the responsibilities of various government agencies to ensure effective planning, data dissemination, and risk management in response to climate change. The legal framework is categorized into two sections: Section 1, Development of Data and Knowledge to Support Strategic Planning and Strengthen Climate Resilience, and Section 2, National Climate Change Adaptation Plan.

Section 1 Development of Data and Knowledge to Support Strategic Planning and Strengthen Climate Resilience aims to establish a robust system for collecting climate-related data and sharing information and knowledge to support national climate adaptation plans and implementation. The DCCE, in collaboration with relevant agencies, must create a comprehensive climate database that includes historical climate data, short- and long-term climate projections, risk assessments, and adaptation strategies. This information must be accessible to the public and regularly updated. Risk assessments play a crucial role in evaluating the potential impacts of climate change across various sectors, such as water, agriculture, and health. The DCCE is responsible for gathering data and information to identify vulnerabilities and inform decision-making entities. Government agencies are required to cooperate in sharing data and participating in these assessments. The goal is to provide a solid knowledge foundation for policies and actions that mitigate climate change risks.

Section 2 National Climate Change Adaptation Plan focuses on creating and implementing an NAP to promote resilience and reduce the impacts of climate change across sectors such as water, agriculture, and health. This plan will guide national and local adaptation strategies, ensuring that all government bodies align their actions with climate adaptation goals. Local governments in vulnerable regions must develop their adaptation action plans, considering local socio-economic and environmental conditions. Regular monitoring, progress reporting, and adjustments are mandated, with oversight from the Cabinet, to address any conflicts or obstacles in implementation. The objective is to ensure coordinated and efficient adaptation efforts at all levels of government.

In conclusion, the framework emphasizes the importance of data collection, risk assessment, and strategic planning for effective climate change adaptation in Thailand. By establishing a national climate information system and fostering inter-agency collaboration, it ensures decisions are based on reliable data and information. The NAP and local action plans promote coordinated action to enhance resilience and reduce vulnerabilities, advancing Thailand's long-term climate resilience.

1.7.3.5 Other

1) Climate Change and Environmental Center (CCE center): The Climate Change and Environmental Center (CCE Center) in Thailand aims to integrate climate adaptation measures to reduce the impacts of climate change. The center works to integrate climate change data with agencies within the Ministry of Natural Resources and Environment and other relevant organizations. It also develops and analyzes real-time climate change data, connecting with climate change coordination centers in each province.
2) Climate Change and Environmental Research Center: Climate Change and Environmental Research Center is responsible for proposing national research frameworks and plans related to climate change. It conducts research, development, and the dissemination of technology and innovations for climate and environmental management. Additionally, it analyzes and exchanges knowledge, technology, and innovations on climate change at national, international, and intergovernmental levels. It also develops methods for environmental sampling and climate change monitoring, including producing reference standards. Furthermore, the organization collaborates with or supports other relevant agencies as directed by the Director general.

1.7.4 Domestic Measurement Reporting and Verification (MRV) System

To monitor the implementation progress, Thailand has developed a domestic MRV system, which operates according to the following structure. The structure of the domestic MRV system is shown in Figure 1-34.

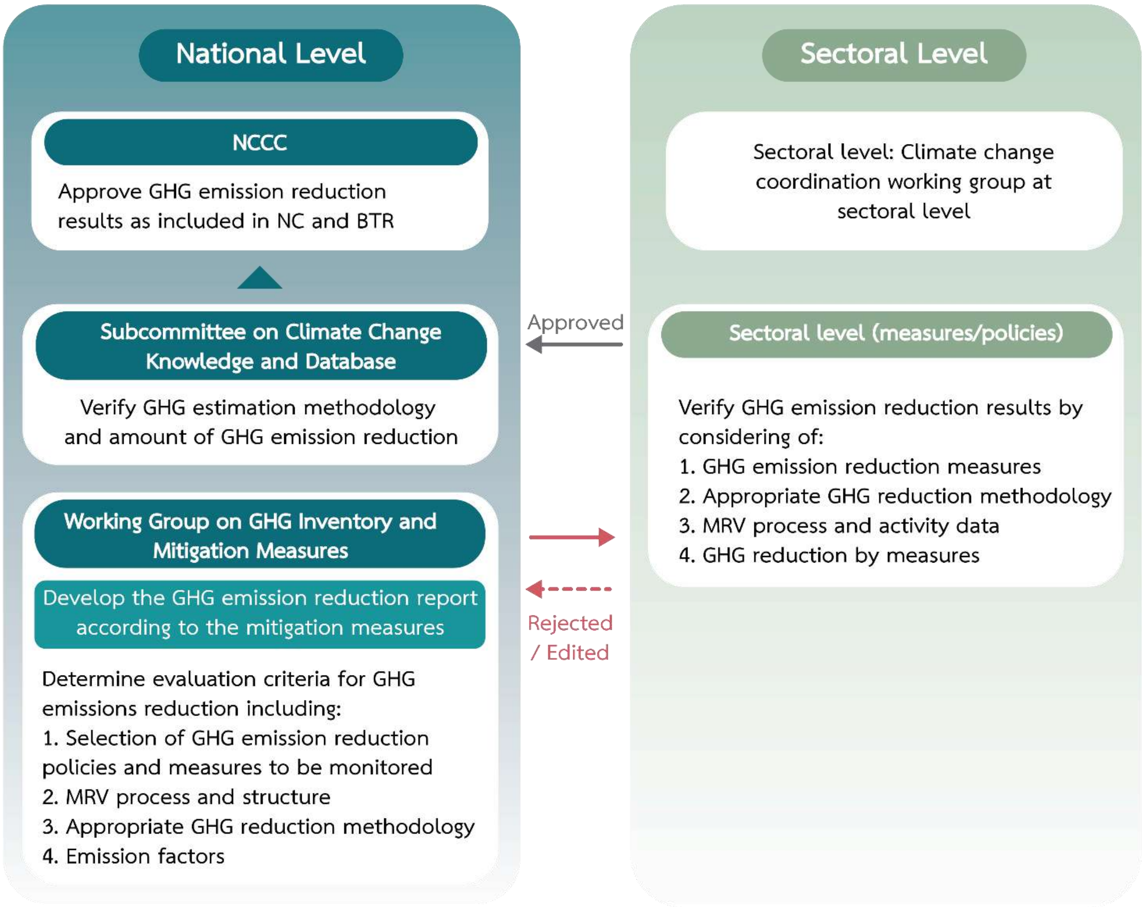


Figure 1-34: The structure of domestic MRV system

National level

- The Working Group on GHG Inventory and Mitigation Measures is responsible for 1) selecting appropriate measures/policies for monitoring and evaluation (M&E) of GHG emissions reduction, identifying Coefficient/Emission Factors, and implementing MRV processes for activity data, and 2) reviewing and providing feedback on the GHG emissions reduction report.
- Subcommittee on Climate Change Knowledge and Database is responsible for further approval on the pre-approved report submitted from sectoral level.
- The National Committee on Climate Change Policy (NCCC) is responsible for the final approval of the GHG emissions reduction report which will later be included in national reports, the Biennial Transparency Report (BTR) and National Communication (NC).

Sectoral level

The main agency at the sectoral level is responsible for the verification of the following key data and approaches after the finalization by the working groups on GHG inventory and mitigation measures as follows: 1) the appropriate measures/policies for M&E of GHG emissions reduction, 2) the methodology for calculation GHG emissions reduction, 3) MRV process for activity data, and 4) the results and GHG emissions reduction report.

Recognizing the importance of a more comprehensive and systematic approach to monitoring and evaluation of mitigation activities, the monitoring and evaluation of the NDC Action Plan 2021–2030 aims to assess the effectiveness of actions, programs, projects, and activities and to measure success against the specified indicators and targets under the NDC Action Plan of Mitigation for 2021–2030. Additionally, it identifies any issues, obstacles, and limitations arising from the implementation to provide data for reviewing and improving the action plan in the future stages. Regarding the NDC Action Plan, the Department of Climate Change and Environment has to establish the structure and mechanism to follow the implementation progress as shown in Figure 1-35. DCCE is developing the NDC tracking system to monitor and report the advancement of mitigation actions. The sector focal points will report their progress, obstacles, and support needs through the online platform annually.

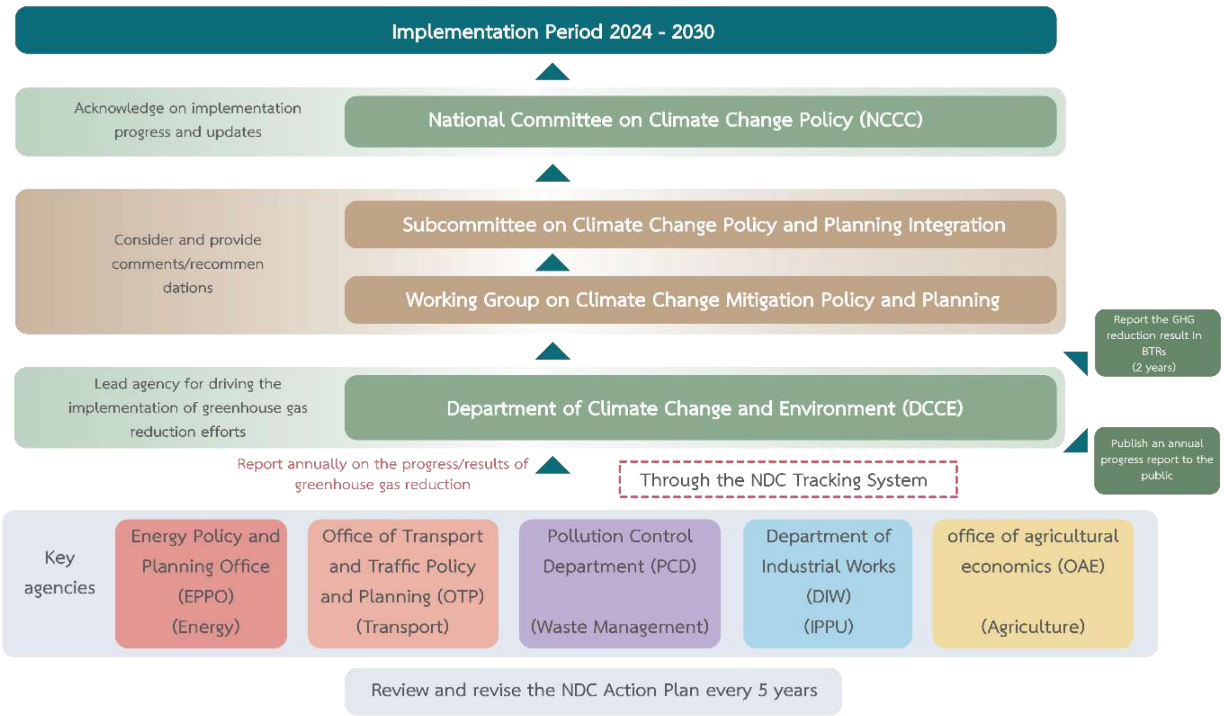


Figure 1-35: The structure and mechanism to follow progress of NDC implementation

Chapter II

NATIONAL GHG INVENTORY

THAILAND'S FIRST BIENNIAL TRANSPARENCY REPORT

CHAPTER 2
NATIONAL GHG INVENTORY

Thailand's GHG inventory was developed and submitted according to Articles 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC) and Article 13 of the Paris Agreement that all Parties to the Convention and the Paris Agreement are required to submit national inventories of greenhouse gas (GHG) emissions and removals. Therefore, Thailand's GHG inventory on emissions and removals and precursors is estimated and reported in this chapter of its first BTR, in accordance with the Modalities, Procedures and Guidelines (MPGs), for the Transparency Framework for Action and Support Referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex).

The estimated emissions in this inventory report were prepared on the basis of the Intergovernmental Panel on Climate Change (IPCC) 2006 IPCC Guidelines for National Greenhouse Gas Inventories (the 2006 IPCC Guidelines), and any subsequent version or refinement of the IPCC guidelines agreed upon by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA). It presents Thailand's national GHG emissions from 2000 to 2022 by sources and removals by sinks. The GHG emissions estimated by Thailand Greenhouse Gas Emission Inventory System (TGEIS) include both direct emissions: Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur Hexafluoride (SF_6) and Nitrogen Trifluoride (NF_3), and indirect emissions: Nitrogen Oxides (NO_x), Carbon Monoxide (CO), Non-Methane Volatile Organic Compounds (NMVOCs) and Sulphur Dioxide (SO_2).

Methodology

Overall, this GHG inventory report has improved on the previous submission. The methodologies and tools used for GHG inventory reporting followed the 2006 IPCC Guidelines, 2003 Good practice guidance for Land Use, Land-Use Change, and Forestry (referred to as GPG 2003), as well as the IPCC's 2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (referred to as GPG 2000), and any subsequent version or refinement of the IPCC guidelines agreed upon by CMA.

Either Tier 1 or Tier 2 methodologies were applied wherever activity data and country-specific emission factors were available. Tier 1 methodologies were employed for all activity data in the Energy sector and almost all in the Industrial Processes and Product Use (IPPU) sector. Tier 2 was adopted in most categories under the Agriculture, Land Use, Land-Use Change, and Forestry, and Waste sectors and some categories under the IPPU sector. GHG emissions from the Energy and IPPU sectors were calculated using default emission factors provided in the 2006 IPCC Guidelines. When available, country-specific emission factors were used for some sub-sectors of the LULUCF, Agriculture and Waste sectors.

Metrices

As per paragraph 37 of the MPGs (Decision 18/CMA.1 Annex), the 100-year time-horizon global warming potential (GWP) values from the IPCC Fifth Assessment Report (AR5) are used to convert GHGs other than CO_2 to CO_2eq. The values are applied for the seven direct GHG gases: CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3. Table 2-1 presents 100-year time-horizon GWP values from IPCC AR5 applied to emissions in Thailand.

Table 2-1: 100-year time-horizon global warming potential (GWP) values from IPCC AR5

Gas	GWP
CO_2	1
CH_4	28
N_2O	265
HFC-23	12,400
HFC-125	3,170
HFC-134a	1,300
HFC-143a	4,800
HFC-152a	138
SF_6	23,500

Assessment of Completeness

A completeness assessment of the inventory was conducted within each source category, following the 2006 IPCC Guidelines. Results of the assessment for the Energy, IPPU, Agriculture, LULUCF, and Waste sectors are presented in the following sections for each sector. In this BTR, categories or processes reported as “NO” represent “not occurring” under a particular source or sink category within Thailand. However, further investigation on their emission possibility and the development of methodologies for estimation will be carried out in accordance with Thailand’s QA/QC plan.

Information on Flexibility

This submission of national greenhouse gas inventory of Thailand refers to several flexibilities. This section summarizes flexibilities in light of Thailand’s capacity with respect to the provision in accordance with the MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex).

Table 2-2: Flexibilities in reporting emissions

Issue	Explanation
1. Time series since 1990	1. The time series of national GHG emissions from sources and removal from sinks starting from 1990 is under planned improvements for all sectors and categories.
2. Tier 2 approach	2. The Tier 2 approach and country-specific emission factors of the key categories are under planned improvements for time series since 1990.

Trends in Greenhouse Gas Emissions and Removals

Thailand's national greenhouse gas inventory reported in this BTR was prepared using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported. Emissions starting from the year 2000 to the latest year of 2022 are estimated and reported following the provision of flexibility in accordance with the MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex), paragraph 57.

Key findings from the National GHG Inventory

In this report, the trends of Thailand's GHG emissions for the period 2000 to 2022, from all emission sources and removals, were evaluated according to the 2006 IPCC Guidelines. The GHG emissions are estimated from the Energy, IPPU, Agriculture, LULUCF, and Waste sectors which include both direct and indirect emissions. Direct GHGs consist of Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs) and Sulphur Hexafluoride (SF_6) whereas indirect GHGs consist of Nitrogen Oxides (NO_x), Carbon Monoxide (CO), Non-Methane Volatile Organic Compounds (NMVOCs) and Sulfur Dioxide (SO_2). Figure 2-1 shows Thailand's national GHG inventory by sector (excluding LULUCF) for 2000 and 2022. (Table 2-3) Total GHG emissions increased from 251,420.82 $ktCO_2eq$ in 2000 to 385,941.14 $ktCO_2eq$ in 2022. The energy sector is the major contributor of GHGs sources with a share of 65.89% in 2022 (254,307.21 $ktCO_2eq$). On the other hand, GHG emissions from the IPPU sector increased sharply from 21,270.17 $ktCO_2eq$ (8.46%) in 2000 to 40,527.22 $ktCO_2eq$ (10.50%) in 2022.

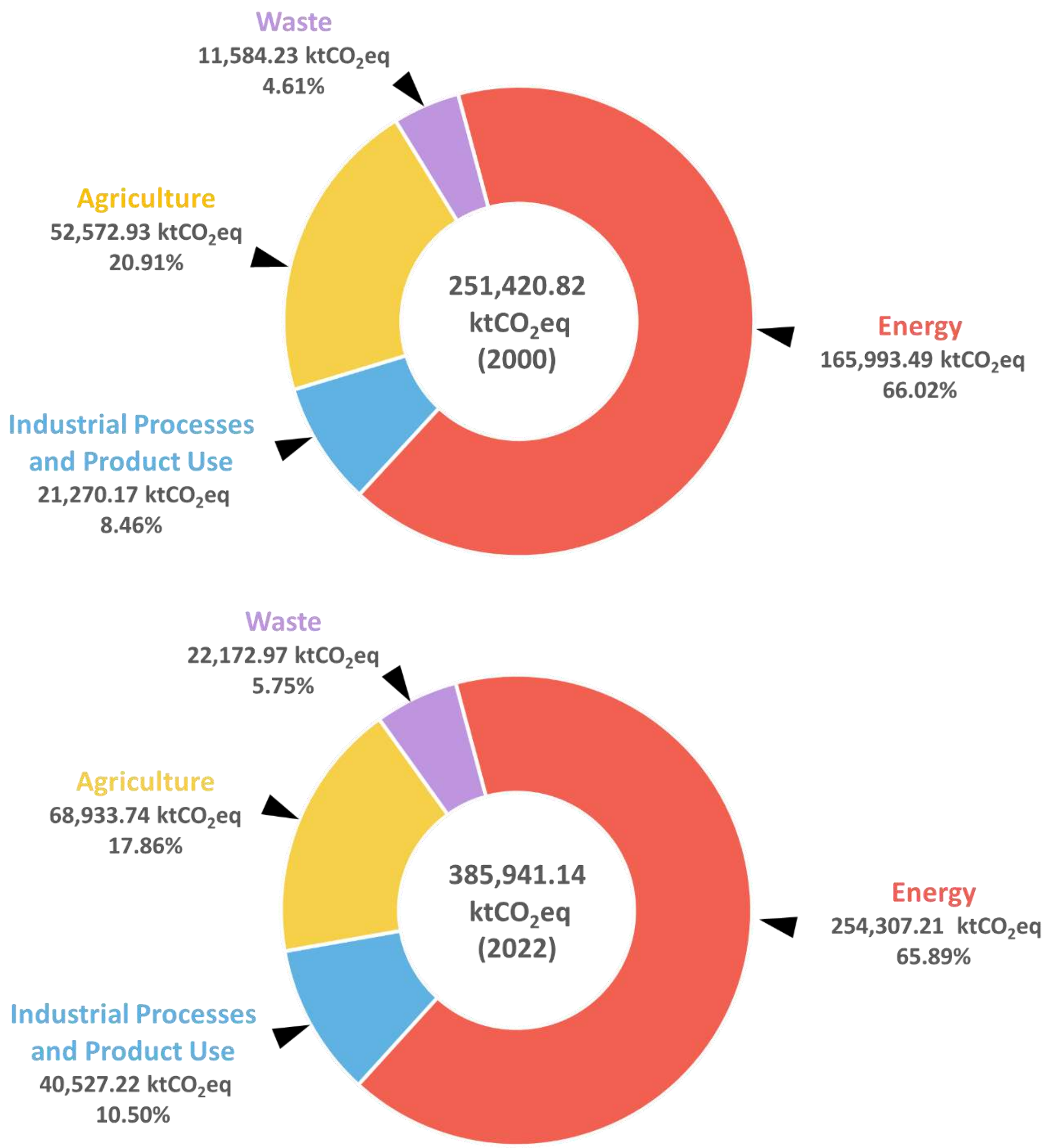


Figure 2-1: Total National GHG emissions by sector (excluding LULUCF) for 2000 and 2022

Trends in Aggregated GHG Emissions

Total GHG emissions (excluding those from LULUCF) increased from 251,420.82 ktCO_2eq in 2000 to 385,941.14 ktCO_2eq in 2022, with an average annual increase of 1.97%. The net removal of CO_2 increased from 45,321.86 ktCO_2eq in 2000 to 107,901.43 ktCO_2eq in 2022. Net GHG emissions therefore increased overall from 206,098.92 ktCO_2eq in 2000 to 278,039.71 ktCO_2eq in 2022, with an average annual increase of 1.37% (Table 2-4, Figure 2-2).

Between 2000 and 2022, the main source of GHG emissions was the Energy sector, which saw an increase from 165,993.49 ktCO_2eq in 2000 to 254,307.21 ktCO_2eq in 2022 (Table 2-4). The proportion of GHG emissions in the Energy sector accounted for 66.02% of total emission sources in 2000, slightly decreasing to 65.89% of total emission sources in 2022. In the same period, the share of emissions from the Agriculture sector decreased from 20.91% in 2000 to 17.86% in 2022, the IPPU sector increased from 8.46% in 2000 to 10.50% in 2022 and the shares of emissions from the Waste sector slightly increased from 4.61% in 2000 to 5.75% in 2022.

Table 2-3: National GHG emissions in CO_2 equivalent by gas and sector in 2022

Sectors	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Total	Share
	ktCO_2eq								
Energy	241,299.47	10,865.53	2,142.21					254,307.21	65.89%
Industrial Processes and Product Use	28,585.13	381.24	421.61	10,383.15		756.09		40,527.22	10.50%
Agriculture	1,065.87	56,593.38	11,274.49					68,933.74	17.86%
Waste	175.49	21,247.11	750.37					22,172.97	5.75%
Total (excluding LULUCF)	**271,125.98**	**89,087.26**	**14,588.67**	**10,383.15**		**756.09**		**385,941.14**	**100%**
Land use, Land- use change and forestry	-108,171.23	211.06	58.75					-107,901.42	
Total (including LULUCF)	**162,954.75**	**89,298.32**	**14,647.86**	**10,383.15**		**756.09**		**278,039.73**	
International Bunkers	11,680.79	14.21	83.70						
Aviation- International Bunkers	6,577.14	1.29	48.75						
Marine- International Bunkers	5,103.65	12.92	34.95						
CO_2 from Biomass	89,389.25								

Table 2-4: Trend of national GHG emissions/removals by sector for 2000-2022

Year	Source category					Net emissions (excluding LULUCF)	Net emissions (including LULUCF)
	Energy	Industrial Processes and Product Use	Agriculture	Waste	LULUCF		
	$ktCO_2eq$						
2000	165,993.49	21,270.17	52,572.93	11,584.23	-45,321.86	251,420.82	206,098.96
2001	173,786.87	22,851.86	53,757.54	12,495.26	-54,351.30	262,891.53	208,540.23
2002	183,231.35	24,914.92	52,186.51	14,210.25	-44,027.61	274,543.02	230,515.41
2003	192,201.46	24,139.99	55,978.17	15,853.86	-45,802.95	288,173.48	242,370.53
2004	209,166.96	25,882.04	55,725.52	16,486.35	-54,094.53	307,260.86	253,166.33
2005	213,347.12	27,753.14	55,412.52	16,847.51	-58,311.85	313,360.29	255,048.43
2006	214,099.94	28,638.69	57,874.22	17,981.81	-61,329.22	318,594.66	257,265.44
2007	220,511.18	30,280.50	61,155.73	18,404.05	-68,334.05	330,351.45	262,017.40
2008	222,914.54	28,741.86	63,403.46	19,614.30	-69,123.15	334,674.15	265,551.01
2009	222,506.38	28,161.54	65,243.35	19,393.56	-71,135.31	335,304.82	264,169.51
2010	234,426.01	29,785.43	64,836.71	17,516.55	-65,765.77	346,564.69	280,798.92
2011	231,177.29	31,084.66	65,291.30	16,521.13	-74,574.83	344,074.38	269,499.55
2012	244,331.59	33,222.21	68,562.67	13,117.17	-80,634.49	359,233.63	278,599.14
2013	237,795.61	33,025.81	62,898.82	15,473.29	-83,060.24	349,193.53	266,133.29
2014	241,257.40	34,537.47	61,731.03	15,754.73	-100,507.61	353,280.63	252,773.02
2015	243,336.90	35,332.02	55,637.00	17,719.75	-87,328.01	352,025.67	264,697.66
2016	255,922.33	36,772.29	55,414.17	18,580.41	-87,040.09	366,689.20	279,649.11
2017	256,586.42	37,628.02	60,345.03	19,582.99	-85,379.74	374,142.46	288,762.72
2018	258,643.32	39,623.31	62,186.58	18,507.80	-85,967.13	378,961.00	292,993.88
2019	262,082.80	37,961.73	60,486.17	18,696.48	-91,986.27	379,227.18	287,240.91
2020	254,827.70	39,609.01	62,065.69	19,799.28	-95,590.26	376,301.68	280,711.42
2021	241,921.78	39,772.72	66,503.31	19,470.95	-98,028.87	367,668.76	269,639.89
2022	254,307.21	40,527.22	68,933.74	22,172.97	-107,901.43	385,941.14	278,039.71

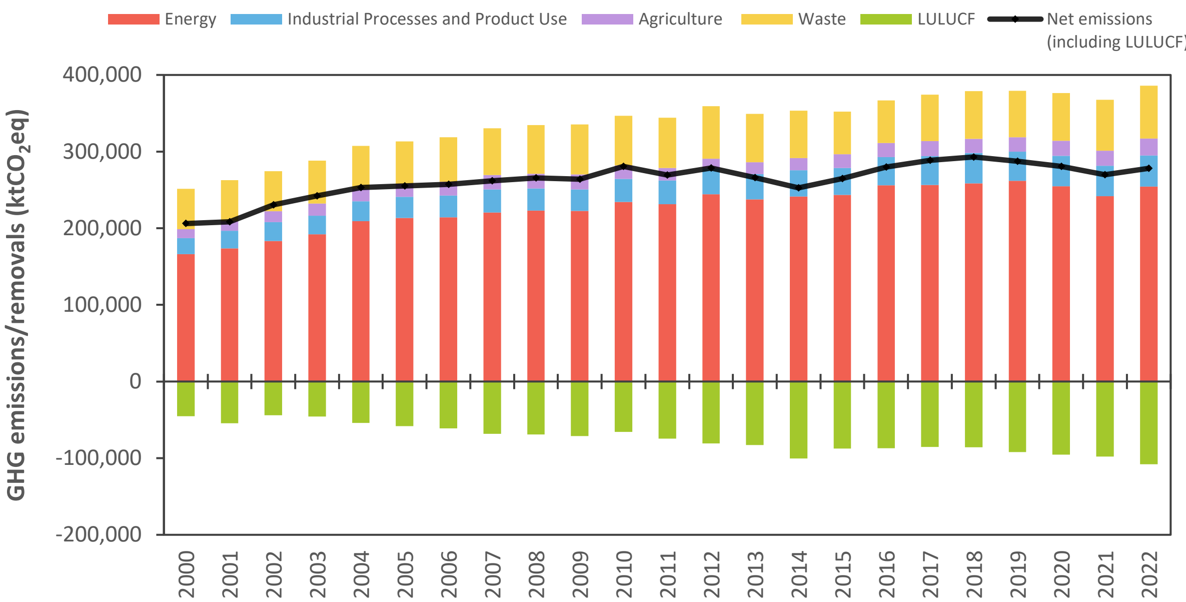


Figure 2-2: Trend of national GHG emissions/removals by sector for 2000-2022

Uncertainty Analysis

The inventories are prepared in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Thus, they typically contain a wide range of emission calculations. Results of the uncertainty analysis of the data showed that the uncertainties of Thailand's national GHG inventory when including data on LULUCF for 2000 and 2022 are approximately 8.88% and 20.98%, respectively. When the LULUCF was excluded from the analysis, uncertainties are 3.21% for 2000 and 10.48% for 2022. (Table 2-5)

Table 2-5: Uncertainties of the Thailand's national GHG inventory

	Trend uncertainty, %											
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Ind. LULUCF	8.88	9.29	10.28	11.16	11.95	14.26	13.54	13.76	14.46	14.77	15.53	15.98
Exd. LULUCF	3.21	3.58	3.96	4.61	4.88	4.99	5.05	5.14	5.52	5.40	5.25	5.39

	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Ind. LULUCF	18.10	19.61	21.19	19.72	19.22	19.33	18.80	18.61	19.90	19.96	20.98
Exd. LULUCF	7.11	7.74	7.75	6.84	7.06	6.83	6.61	6.76	7.38	7.83	10.48

Key Category Analysis

Key category analysis (KCA) presents the importance of emission sources and sinks. The 'Key categories' are defined as the emission sources and sinks that constitute 95% of total annual emissions when ranked from the greatest to the lowest contribution. A 'key source' has a significant influence on the national inventory of direct GHG emissions in terms of the absolute emissions level. The KCA reported in this inventory follows the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and is estimated for both level and trend assessments. The results of the 2022 level assessment are presented in Table 2-6, and those of the 2022 trend assessment are available in Table 2-7. There are 17 key categories in the level assessment, among which cropland remaining cropland led the KCA, followed by main activity electricity and heat production, road transportation, manufacturing industries and construction, and rice cultivation. Results of the KCA changed under trend assessment, where cropland remaining cropland led the KCA, followed by land converted to cropland, forest land remaining forest land, manufacturing industries and construction, and rice cultivation.

Table 2-6: Key category analysis for the year 2022: Approach 1 – Level assessment

Category code	IPCC source category	GHG	Base year estimate 2000 ($ktCO_2eq$)	Current year estimate 2022 ($ktCO_2eq$)	$L_{x,t}$	Cumulative total of Level
4B	Cropland remaining cropland	CO_2	36,665.42	91,486.96	0.18	0.18
1A1a	Main activity electricity and heat production	CO_2	58,182.12	81,695.57	0.16	0.33
1A3b	Road transportation	CO_2	45,479.14	72,914.82	0.14	0.47
1A2	Manufacturing industries and construction	CO_2	31,940.86	61,840.83	0.12	0.59
3I	Rice cultivation	CH_4	29,739.65	33,886.79	0.07	0.66
4A	Forest land remaining forest land	CO_2	34,311.02	29,328.06	0.06	0.71
3A	Enteric fermentation	CH_4	10,512.53	18,347.24	0.04	0.75
2A1	Cement production	CO_2	14,630.20	15,803.16	0.03	0.78
1A4	Other sectors	CO_2	11,044.67	12,726.41	0.02	0.80
4C	Land converted to cropland	CO_2	23,236.24	12,489.38	0.02	0.83
5D	Wastewater treatment and discharge	CH_4	7,177.19	11,164.61	0.02	0.85
2B8	Petrochemical and carbon black production	CO_2	5,089.85	10,865.46	0.02	0.87
5A	Solid waste disposal	CH_4	3,861.31	9,988.82	0.02	0.89
1A1b	Petroleum refining	CO_2	6,897.35	9,574.94	0.02	0.91
1B2	Oil	CH_4	6,928.60	7,929.46	0.02	0.92
3F	Direct N_2O emission from managed soils	N_2O	5,589.48	6,961.78	0.01	0.94
2F1	Refrigeration and Air Conditioning	HFC-125	0.64	4,561.65	0.01	0.95

Remark: $L_{x,t}$ means level assessment for source or sink x in latest inventory year.

Table 2-7: Key category analysis for the year 2022: Approach 1 – Trend assessment

Category code	IPCC source category	GHG	Base year estimate 2000 ($ktCO_2eq$)	Current year estimate 2022 ($ktCO_2eq$)	$T_{x,t}$	% Contribution to trend	Cumulative total of trend
4B	Cropland remaining cropland	CO_2	36,665.42	91,486.96	0.11	22.64	22.64
4C	Land converted to cropland	CO_2	23,236.24	12,489.38	0.06	13.68	36.32
4A	Forest land remaining forest land	CO_2	34,311.02	29,328.06	0.06	13.50	49.82
1A2	Manufacturing industries and construction	CO_2	31,940.86	61,840.83	0.04	8.72	58.54
3I	Rice cultivation	CH_4	29,739.65	33,886.79	0.03	6.48	65.02
2A1	Cement Production	CO_2	14,630.20	15,803.16	0.02	3.72	68.74
1A1a	Main activity electricity and heat production	CO_2	58,182.12	81,695.57	0.01	3.19	71.93
1A3b	Road transportation	CO_2	45,479.14	72,914.82	0.01	3.09	75.02
2F1	Refrigeration and Air Conditioning	HFC-125	0.64	4,561.65	0.01	2.81	77.83
5A	Solid waste disposal	CH_4	3,861.31	9,988.82	0.01	2.60	80.43
1A4	Other sectors	CO_2	11,044.67	12,726.41	0.01	2.32	82.75
2B8	Petrochemical and carbon black production	CO_2	5,089.85	10,865.46	0.01	2.01	84.76
3A	Enteric fermentation	CH_4	10,512.53	18,347.24	0.01	1.63	86.40
1B2	Oil and Natural Gas	CH_4	6,928.60	7,929.46	0.01	1.49	87.88
2F1	Refrigeration and air conditioning	HFC-32	0.00	2,349.19	0.01	1.45	89.33
4E2	Biomass Burning (Cropland)	CH_4	1,577.26	200.50	0.01	1.33	90.66
2F1	Refrigeration and air conditioning	HFC-134a	38.63	2,202.75	0.01	1.32	91.98
3F	Direct N2O emission from managed soils	N_2O	5,589.48	6,961.78	0.00	0.85	92.83
2F1	Refrigeration and air conditioning	HFC-143a	1.05	1,239.42	0.00	0.76	93.60
1A4	Other Sectors	CH_4	1,495.27	1,122.75	0.00	0.68	94.28
1B1	Solid fuels	CH_4	1,495.27	1,122.75	0.00	0.68	94.71
1A1b	Petroleum refining	CO_2	861.84	563.00	0.00	0.44	95.15

Remark: $T_{x,t}$ means trend assessment of source or sink category x in year t as compared to the base year.

National Emission Trends by Greenhouse Gases: CO_2, CH_4, N_2O & F-gases

National Emission Trends of CO_2 by Sector

For CO_2 emissions by sources in the time series of 2000-2022, the trend of CO_2 emissions in all sectors increased from 2000, but decreased in recent years. Trends of the Energy Industries (1A1) decreased after 2018; the Manufacturing Industries and Construction (1A2) decreased after 2021; the Transport sector (1A3) decreased after 2021; the IPPU sector decreased after 2019; Other sectors (1A4) decreased after 2013 while CO_2 emissions in the Waste and Agriculture sectors are unchanged. (Figure 2-3). The decreasing CO_2 emissions during 2000-2022 may have resulted from COVID-19 lockdowns by Thailand. Further observation of these emissions in 2023 and 2024, after the pandemic, is necessary for a conclusion in the next BTR submission.

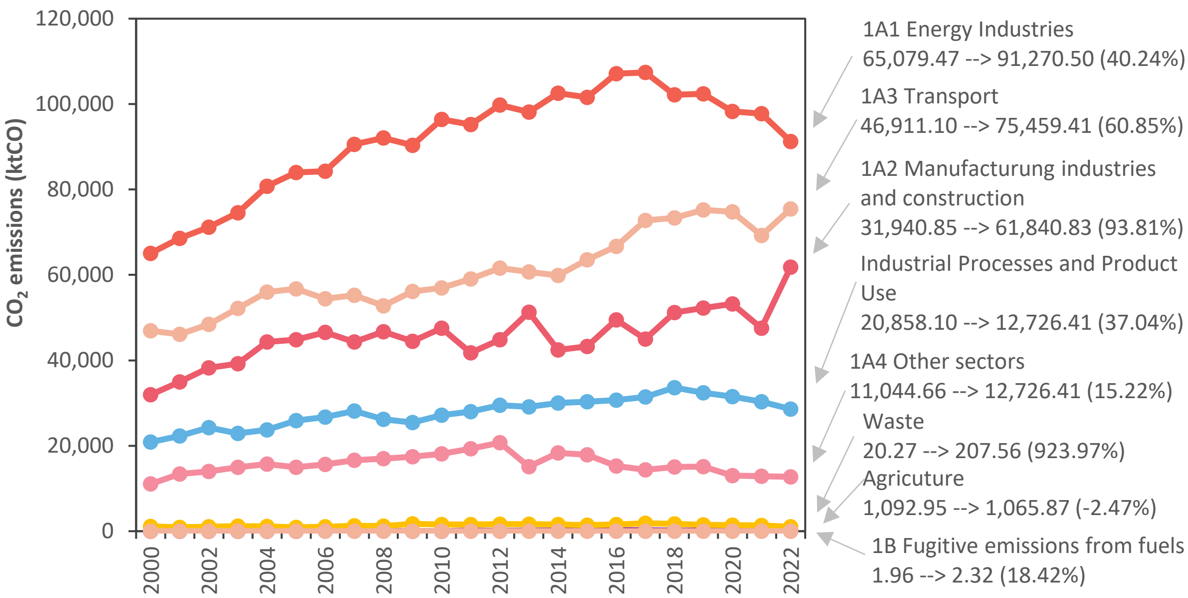


Figure 2-3: Trends of CO_2 emissions in each sector for 2000-2022

National CO_2 Emissions per Capita

Figure 2-4 shows trends in total CO_2 emissions and CO_2 emissions per capita for 2000-2022. After the COVID-19 pandemic in 2020 and 2021, CO_2 emissions began increasing in 2022. Thailand's per capita CO_2 emissions were found to be 2.86 tonnes CO_2 per capita in 2000 and 4.10 tonnes CO_2 per capita in 2022 (Figure 2-4). However, in the time series, Thailand's per capita CO_2 emissions are found to be lower than the world average.

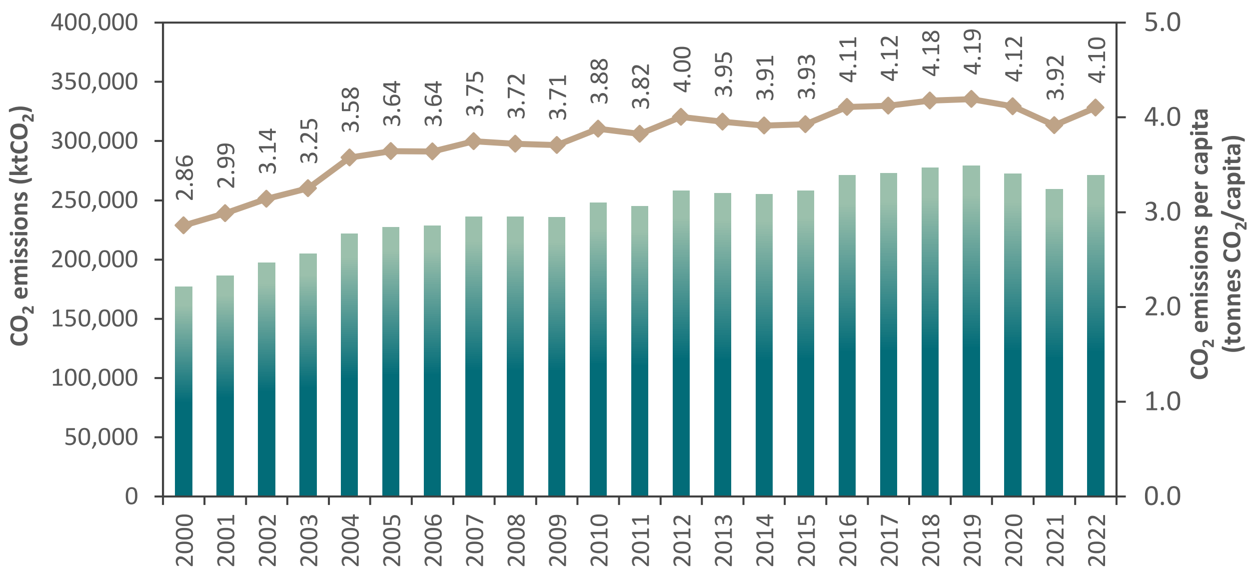


Figure 2-4: Trends in total CO_2 emissions and CO_2 emissions per capita for 2000-2022

National GHG Emissions by Gas

In terms of GHG emissions by gas, CO_2 dominated in GHG emissions in 2022 (271,125.96 ktCO_2eq, 70.25%), followed by CH_4 (89,087.26 ktCO_2eq, 23.08%), N_2O (14,588.68 ktCO_2eq, 3.78%), and HFCs (10,383.15 ktCO_2eq, 2.69%) (Figure 2-5). In 2022, the Energy sector was the largest CO_2 source; the Agriculture sector was the largest CH_4 and N_2O source; and the IPPU sector was the largest HFCs source. (Table 2-8).

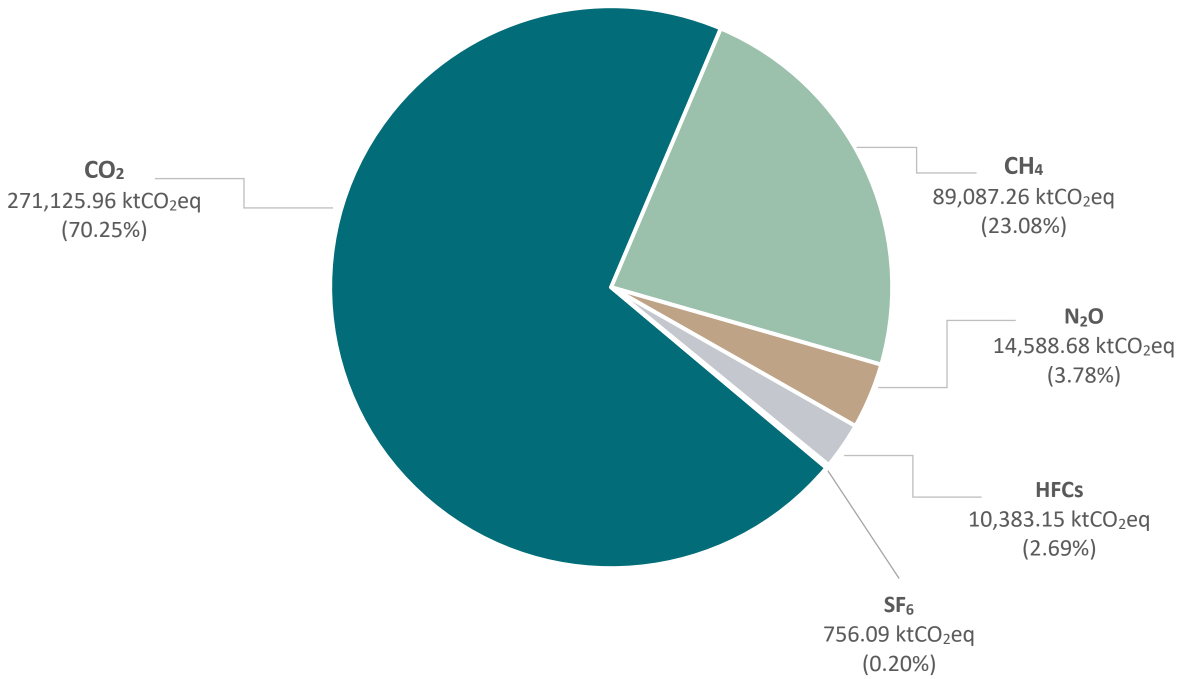


Figure 2-5: Shares of gases in total GHG emissions in 2022 (excluding LULUCF)

Table 2-8: Sectoral contributions to GHG emissions in 2022 (excluding LULUCF)

2022	CO_2	CH_4	N_2O	HFCs, PFCs, SF_6, NF_3
	ktCO_2eq			
Energy	241,299.47	10,865.53	2,142.21	0.00
Industrial Processes and Product Use	28,585.13	381.24	421.61	11,139.24
Agriculture	1,065.87	56,593.38	11,274.49	0.00
Waste	175.49	21,247.11	750.37	0.00

Emissions for Precursor Gases by Sector

The indirect gases, including NO_x, CO, NMVOCs, and SO_2, have been calculated and reported. In 2022, for NO_x emissions, the Energy sector was the key emission source (96.67%); for CO emissions, the Energy sector contributed 75.29% while the Agriculture sector contributed 23.03%; for NMVOC emissions, the Energy sector was the main source (99.25%); for SO_2 emissions, the Energy sector was the main contributor (98.86%). Most precursor gases come from the use of fuels in the Energy sector. (Table 2-9, Figure 2-6)

Table 2-9: Precursor gas emissions by source category in 2022.

Sectors	NO_x		CO		NMVOC		SO_2	
	kt	%	kt	%	kt	%	kt	%
Energy	1,391.90	96.67	5,395.60	75.29	823.29	99.25	535.56	98.86
IPPU	1.32	0.09	4.928	0.07	6.25	0.75	6.16	1.14
Agriculture	44.84	3.11	1,650.19	23.03	0.00	0.00	0.00	0.00
Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LULUCF	1.77	0.12	115.28	1.61	0.00	0.00	0.00	0.00
Total	**1,439.83**	**100.00**	**7,166.00**	**100.00**	**829.54**	**100.00**	**541.72**	**100.00**

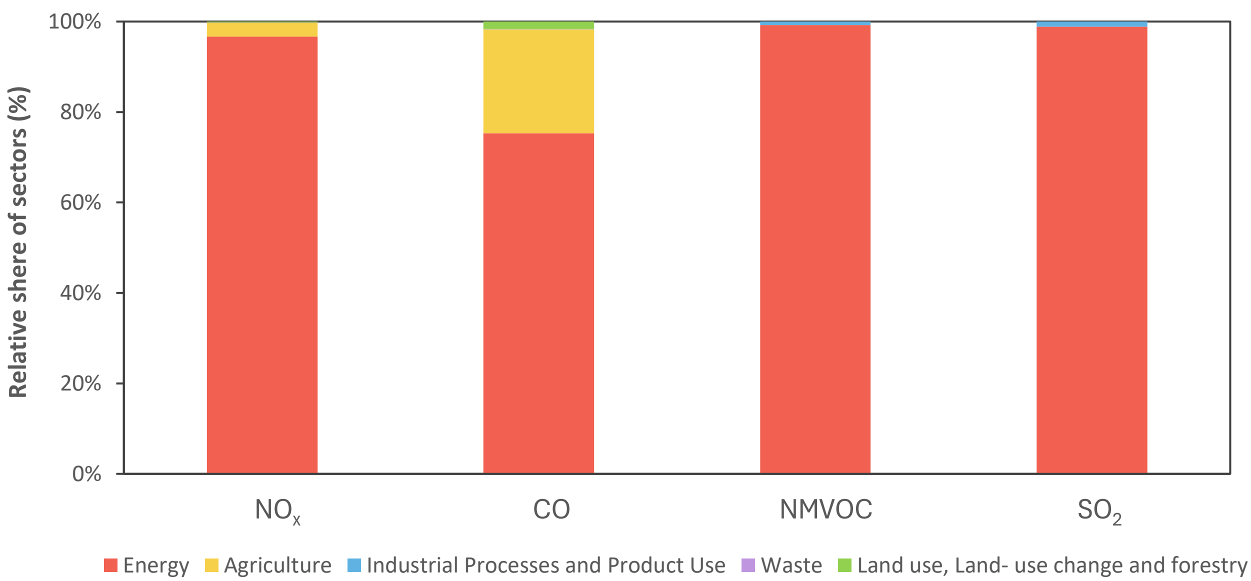


Figure 2-6: Sectoral contributions to precursor gas emissions in 2022 (including LULUCF)

Emission Trends of Precursor Gases

The trends of indirect GHG emissions for the period from 2000 to 2022 are shown in Table 2-10. The estimated indirect GHG emissions are as follows:

- NO_x: 927.86 kt (2000) to 1,439.83 kt (2022) – an average annual increase of 2.02%
- CO: 5,104.71 kt (2000) to 7,166.00 kt (2022) – an average annual increase of 1.55%
- NMVOCs: 731.43 kt (2000) to 829.54 kt (2022) – an average annual increase of 0.57%
- SO_2: 594.97 kt (2000) to 541.72 kt (2022) – an average annual decrease of -0.43%

Table 2-10: Trend of indirect GHG emissions by types of gases for 2000-2022

Year	Indirect Gases			
	NO_x	CO	NMVOC	SO_2
2000	927.86	5,104.71	731.43	594.97
2001	972.80	5,150.04	746.09	643.73
2002	1,025.58	5,402.32	828.21	688.52
2003	1,097.05	5,798.58	878.38	617.62
2004	1,185.43	5,958.74	895.95	719.97
2005	1,192.67	5,789.41	828.46	703.03
2006	1,182.02	5,984.43	853.23	692.78
2007	1,216.14	6,114.82	867.66	627.17
2008	1,208.83	6,259.45	833.73	631.13
2009	1,233.14	6,371.78	856.09	600.83
2010	1,272.54	6,508.22	864.60	633.92
2011	1,295.37	6,782.25	900.13	607.29
2012	1,356.24	7,408.00	896.68	564.75
2013	1,308.56	7,297.66	892.23	499.92
2014	1,329.90	7,130.67	980.53	447.44
2015	1,351.85	7,153.16	1,033.66	416.77
2016	1,385.71	7,254.31	971.07	452.09
2017	1,422.45	7,398.04	1,008.05	425.62
2018	1,450.91	7,798.64	1,057.86	497.23
2019	1,474.62	7,710.58	1,342.55	506.17
2020	1,422.53	7,189.01	1,309.22	525.55
2021	1,350.76	6,815.69	977.18	448.15
2022	1,439.83	7,166.00	829.54	541.72
Average Annual Growth Rate	2.02%	1.55%	0.57%	-0.43%

2.1 ENERGY SECTOR

Greenhouse Gas Emissions in the Energy Sector in 2022

Table 2-11 presents the methodology used in the Energy sector by following the 2006 IPCC Guidelines. However, only Tier 1 activity data and default emission factors are adopted as mentioned in the use of flexibility in light of Thailand's capacity with respect to the provision in accordance with the MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex).

Total direct GHG emissions from the Energy sector in 2022 were estimated to be 254,307.21 ktCO_2eq. The majority of GHG emissions in the Energy sector were generated by fuel combustion, consisting of 1A1 Energy industries at around 92,222.65 ktCO_2eq (36.26%). GHG emissions from Transport, Manufacturing Industries and Construction, and Other Sectors were 77,021.31 ktCO_2eq (30.29%), 62,578.28 ktCO_2eq (24.61%), and 13,990.18 ktCO_2eq (5.50%), respectively. Fugitive emissions from solid fuels, and oil & natural gas comprised only 563 ktCO_2eq or 0.22%, and 7,931.78 ktCO_2eq or 3.12% of total GHG emissions from the Energy sector, respectively (Figure 2-7). Details of GHG emissions in the Energy sector by types of gases and sources in 2022 are presented in Table 2-12.

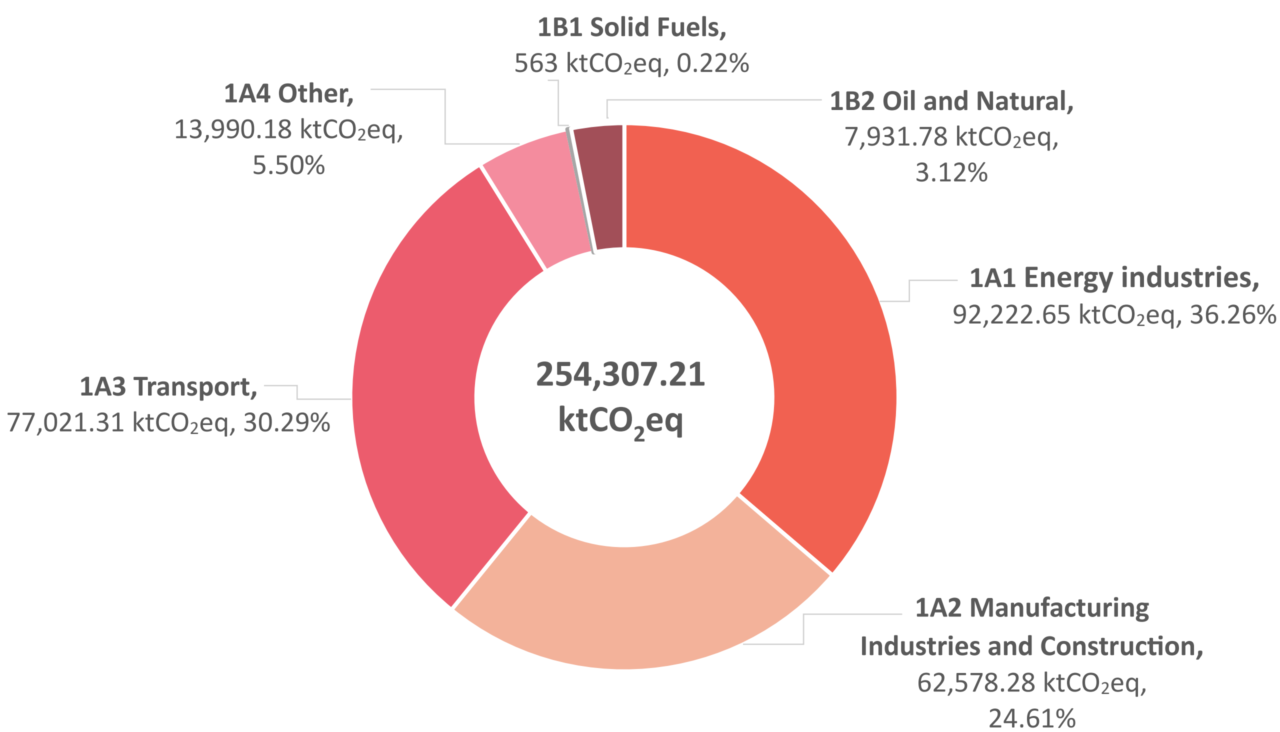


Figure 2-7: GHG emissions in Energy sector in 2022

Table 2-11: Methodologies used in the Energy sector.

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O		HFCs		PFCs		SF6		NO_x		CO		NMVOC		SO_2	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1 Energy	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A Fuel Combustion	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A1 Energy Industries	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A1a Electricity and Heat Production	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A1b Petroleum Refining	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A2 Manufacturing Industries and Construction	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A3 Transport	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A3a Civil Aviation	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A3b Road Transportation	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A3c Railways	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A3d Water-borne navi.	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A4 Other Sector	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A4a Commercial / Inst.	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A4b Residential	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A4c Agriculture / Forestry / Fishing & Farms	T1	D	T1	D	T1	D							T1	D	T1	D	T1	D	T1	D
1A5 Non-specified																				
1B Fugitive emissions	T1	D	T1	D													T1	D		
1B1 Solid Fuels			T1	D																
1B2 Oil and Natural Gas	T1	D	T1	D													T1	D		
1B3 Other emissions from energy production																				
1C Carbon dioxide transport, Injection and geological storage																				
1C1 Transport of CO_2																				
1C2 Injections and Storage																				
1C3 Other																				

Note: T1: IPCC Tier 1, and D: IPCC default.

Table 2-12: GHG emissions from various sources in the Energy sector in 2022

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4		N_2O		HFCs	PFCs	SF6	NO_x	CO	NMVOC	SO_2	Total
	$ktCO_2eq$	$ktCO_2eq$	kt	$ktCO_2eq$	kt	$ktCO_2eq$	$ktCO_2eq$	$ktCO_2eq$	$ktCO_2eq$	kt	kt	kt	kt	$ktCO_2eq$
1. Energy	241,299.48	NO	388.05	10,865.53	8.08	2,142.20				1,391.90	5,395.60	823.29	535.56	254,307.21
1A Fuel Combustion	241,297.16	NO	84.75	2,373.07	8.08	2,142.20				1,391.90	5,395.60	729.51	535.56	245,812.43
1A1 Energy Industries	91,270.50	NO	13.34	373.58	2.18	578.58				297.50	441.22	27.54	48.71	92,222.65
1A1a Main Activity Electricity and Heat Production	81,695.57	NO	12.95	362.60	2.10	557.81				271.38	439.26	26.89	48.71	82,615.97
1A1b Petroleum Refining	9,574.94	NO	0.39	10.97	0.08	20.77				26.13	1.96	0.65	NA	9,606.68
1A2 Manufacturing Industries and Construction	61,840.83	NO	11.34	317.59	1.58	419.86				207.15	1,105.68	22.55	452.55	62,578.28
1A3 Transport	75,459.41	NO	19.97	559.16	3.78	1,002.75				762.53	3,070.79	579.09	9.32	77,021.31
1A3a Civil Aviation	1,725.39	NO	0.01	0.34	0.05	12.79				7.24	2.41	1.21	NA	1,738.51
1A3b Road Transportation	72,914.82	NO	19.88	556.65	3.64	964.31				739.55	3,057.32	575.68	9.32	74,435.79
1A3c Railways	206.69	NO	0.01	0.38	0.08	21.17				3.35	2.79	0.56	NA	228.24
1A3d Water-borne navigation	612.51	NO	0.06	1.78	0.02	4.47				12.40	8.27	1.65	NA	618.76
1A4 Other Sector	12,726.41	NO	40.10	1,122.75	0.53	141.02				124.71	777.92	100.32	24.98	13,990.18
1A5 Non-specified	NO	NO	NO	NO	NO	NO				NO	NO	NO	NO	NO
1B Fugitive emissions from fuels	2.32	NO	303.3	8,492.46	NO	NO				NO	NO	93.79	NO	8,494.78
1B1 Solid Fuels	NO	NO	20.11	563.00	NO	NO				NO	NO	NO	NO	563.00
1B2 Oil and Natural Gas	2.32	NO	283.19	7,929.46	NO	NO				NO	NO	93.79	NO	7,931.78
1B3 Other emissions from energy production	NO	NO	NO	NO	NO	NO				NO	NO	NO	NO	NO
1C Carbon dioxide transport, Injection and Geological storage	NO	NO	NO	NO	NO	NO				NO	NO	NO	NO	NO
1C1 Transport of CO_2	NO	NO	NO	NO	NO	NO				NO	NO	NO	NO	NO
1C2 Injections and Storage	NO	NO	NO	NO	NO	NO				NO	NO	NO	NO	NO
1C3 Other	NO	NO	NO	NO	NO	NO				NO	NO	NO	NO	NO
Memo item														
International Bunkers	11,680.79	NO	0.51	14.21	0.32	83.70				126.50	75.14	17.79	NO	11,778.70
Aviation-International Bunkers	6,577.14	NO	0.05	1.29	0.18	48.75				27.60	9.20	4.60	NO	6,627.18
Marine-International Bunkers	5,103.65	NO	0.46	12.92	0.13	34.95				98.91	65.94	13.19	NO	5,151.52
CO_2 from Biomass	89,389.25													89,389.25

Uncertainty of Emissions Estimation in the Energy Sector

Combining uncertainties of activity data uncertainty and emission factor uncertainty follows 2006 IPCC Guidelines (Vol 1, Page 3.28, Eq. 3.1). The combined uncertainties as percent of emissions in 2022 also follow 2006 IPCC Guidelines (Vol 1, Page 3.28, Eq. 3.2). Results of combined uncertainties in the Energy sector are presented in Table 2-13.

EQUATION 3.1
COMBINING UNCERTAINTIES – APPROACH 1 – MULTIPLICATION

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2}$$

Where:

U_{total} = Combining uncertainties
U_1 = Activity data's uncertainty
U_2 = Emission factor's uncertainty

EQUATION 3.2
COMBINING UNCERTAINTIES – APPROACH 1 – ADDITION AND SUBTRACTION

$$U_{total} = \frac{\sqrt{(U_1 \bullet x_1)^2 + (U_2 \bullet x_2)^2 + \ldots + (U_n \bullet x_n)^2}}{|x_1 + x_2 + \ldots + x_n|}$$

Where:

U_{Total} = the percentage uncertainty in the sum of the quantities (half the 95 percent confidence interval divided by the total (i.e., mean) and expressed as a percentage). This term 'uncertainty' is thus based upon the 95 percent confidence interval

x_i and U_i = the uncertain quantities and the percentage uncertainties associated with them, respectively.

Table 2-13: Uncertainty of Emissions Estimation in the Energy Sector for 2020-2022

Uncertainty of Emissions Estimation in the Energy Sector in 2020							
IPCC Category	**GHG**	**Emissions or removals in 2000**	**Emissions or removals in 2020**	**Activity Data (AD) Uncertainty**	**Emission Factor (EF) Uncertainty**	**Combined Uncertainty**	**Combined Uncertainty as % of Emissions in 2020**
		$ktCO_2eq$	$ktCO_2eq$	%	%	%	%
1A1 Energy Industries							
1A1 Energy Industries	CO_2	65,677.26	98,320.20	5.00	7.00	8.60	0.11
1A1 Energy Industries	CH_4	33.71	321.72	5.00	150.00	150.08	0.00
1A1 Energy Industries	N_2O	128.42	515.84	5.00	200.00	200.06	0.00
1A2 Manufacturing Industries and Construction							
1A2 Manufacturing Industries and Construction	CO_2	30,100.43	53,206.69	5.00	7.00	8.60	0.03
1A2 Manufacturing Industries and Construction	CH_4	48.13	325.12	5.00	150.00	150.08	0.00
1A2 Manufacturing Industries and Construction	N_2O	92.26	430.47	5.00	200.00	200.06	0.00
1A3 Transport							
1A3a Civil Aviation	CO_2	928.99	1,879.08	5.00	5.00	7.07	0.00
1A3a Civil Aviation	CH_4	0.17	0.37	5.00	100.00	100.12	0.00
1A3a Civil Aviation	N_2O	7.91	13.93	5.00	150.00	150.08	0.00
1A3b Road Transportation	CO_2	45,479.14	72,215.73	5.00	5.00	7.07	0.04
1A3b Road Transportation	CH_4	225.74	580.36	5.00	194.85	194.91	0.00
1A3b Road Transportation	N_2O	677.82	955.12	5.00	202.50	202.56	0.01
1A3c Railways	CO_2	296.86	206.69	5.00	2.02	5.39	0.00
1A3c Railways	CH_4	0.42	0.38	5.00	60.10	60.31	0.00
1A3c Railways	N_2O	34.14	21.17	5.00	66.67	66.86	0.00
1A3d Water-borne Navigation	CO_2	186.21	506.64	5.00	1.50	5.22	0.00
1A3d Water-borne Navigation	CH_4	0.44	1.48	5.00	50.00	50.25	0.00
1A3d Water-borne Navigation	N_2O	1.5	3.70	5.00	140.00	140.09	0.00
1A4 Other Sectors							
1A4 Other sectors	CO_2	10,619.63	13,008.30	10.00	7.00	12.21	0.00
1A4 Other sectors	CH_4	28.06	1,296.71	10.00	150.00	150.33	0.01
1A4 Other sectors	N_2O	17.36	161.56	10.00	200.00	200.25	0.00
1B Fugitive Emissions							
1B1 Solid Fuels	CH_4	769.43	546.88	2.00	150.00	150.01	0.00
1B2a Oil	CO_2	0.01	0.28	5.00	500.00	500.02	0.00
1B2a Oil	CH_4	46.51	158.06	5.00	500.00	500.02	0.00
1B2b Natural Gas	CO_2	1.96	2.88	5.00	250.00	250.05	0.00
1B2b Natural Gas	CH_4	6,153.81	10,148.36	5.00	250.00	250.05	0.99
Total		161,556.32	254,827.70				**1.20**
				Percentage uncertainty in total inventory			**10.94**

Remark: 0.00 means less than 0.005

Uncertainty of Emissions Estimation in the Energy Sector in 2021							
IPCC Category	GHG	Emissions or removals in 2000	Emissions or removals in 2021	Activity Data (AD) Uncertainty	Emission Factor (EF) Uncertainty	Combined Uncertainty	Combined Uncertainty as % of Emissions in 2021
		$ktCO_2eq$	$ktCO_2eq$	%	%	%	%
1A1 Energy Industries							
1A1 Energy Industries	CO_2	65,677.26	97,758.62	5.00	7.00	8.60	0.12
1A1 Energy Industries	CH_4	33.71	344.01	5.00	150.00	150.08	0.00
1A1 Energy Industries	N_2O	128.42	541.04	5.00	200.00	200.06	0.00
1A2 Manufacturing Industries and Construction							
1A2 Manufacturing Industries and Construction	CO_2	30,100.43	47,538.18	5.00	7.00	8.60	0.03
1A2 Manufacturing Industries and Construction	CH_4	48.13	253.66	5.00	150.00	150.08	0.00
1A2 Manufacturing Industries and Construction	N_2O	92.26	336.93	5.00	200.00	200.06	0.00
1A3 Transport							
1A3a Civil Aviation	CO_2	928.99	723.04	5.00	5.00	7.07	0.00
1A3a Civil Aviation	CH_4	0.17	0.14	5.00	100.00	100.12	0.00
1A3a Civil Aviation	N_2O	7.91	5.36	5.00	150.00	150.08	0.00
1A3b Road Transportation	CO_2	45,479.14	67,825.86	5.00	5.00	7.07	0.04
1A3b Road Transportation	CH_4	225.74	515.80	5.00	194.85	194.91	0.00
1A3b Road Transportation	N_2O	677.82	900.46	5.00	202.50	202.56	0.01
1A3c Railways	CO_2	296.86	199.23	5.00	2.02	5.39	0.00
1A3c Railways	CH_4	0.42	0.37	5.00	60.10	60.31	0.00
1A3c Railways	N_2O	34.14	20.41	5.00	66.67	66.86	0.00
1A3d Water-borne Navigation	CO_2	186.21	491.78	5.00	1.50	5.22	0.00
1A3d Water-borne Navigation	CH_4	0.44	1.43	5.00	50.00	50.25	0.00
1A3d Water-borne Navigation	N_2O	1.5	3.59	5.00	140.00	140.09	0.00
1A4 Other Sectors							
1A4 Other sectors	CO_2	10,619.63	12,853.41	10.00	7.00	12.21	0.00
1A4 Other sectors	CH_4	28.06	1,101.45	10.00	150.00	150.33	0.00
1A4 Other sectors	N_2O	17.36	138.98	10.00	200.00	200.25	0.00
1B Fugitive Emissions							
1B1 Solid Fuels	CH_4	769.43	586.95	2.00	150.00	150.01	0.00
1B2a Oil	CO_2	0.01	0.17	5.00	500.00	500.02	0.00
1B2a Oil	CH_4	46.51	138.37	5.00	500.00	500.02	0.00
1B2b Natural Gas	CO_2	1.96	2.74	5.00	250.00	250.05	0.00
1B2b Natural Gas	CH_4	6,153.81	9,639.78	5.00	250.00	250.05	0.99
Total		161,556.32	241,921.79				**1.20**
				Percentage uncertainty in total inventory			**10.97**

Remark: 0.00 means less than 0.005

Uncertainty of Emissions Estimation in the Energy Sector in 2022							
IPCC Category	GHG	Emissions or removals in 2000	Emissions or removals in 2022	Activity Data (AD) Uncertainty	Emission Factor (EF) Uncertainty	Combined Uncertainty	Combined Uncertainty as % of Emissions in 2022
		$ktCO_2eq$	$ktCO_2eq$	%	%	%	%
1A1 Energy Industries							
1A1 Energy Industries	CO_2	65,677.26	91,270.50	5.00	7.00	8.60	0.10
1A1 Energy Industries	CH_4	33.71	373.58	5.00	150.00	150.10	0.00
1A1 Energy Industries	N_2O	128.42	578.58	5.00	200.00	200.10	0.00
1A2 Manufacturing Industries and Construction							
1A2 Manufacturing Industries and Construction	CO_2	30,100.43	61,840.83	5.00	7.00	8.60	0.04
1A2 Manufacturing Industries and Construction	CH_4	48.13	317.59	5.00	150.00	150.10	0.00
1A2 Manufacturing Industries and Construction	N_2O	92.26	419.86	5.00	200.00	200.10	0.00
1A3 Transport							
1A3a Civil Aviation	CO_2	928.99	1,725.39	5.00	5.00	7.10	0.00
1A3a Civil Aviation	CH_4	0.17	0.34	5.00	100.00	100.10	0.00
1A3a Civil Aviation	N_2O	7.91	12.79	5.00	150.00	150.10	0.00
1A3b Road Transportation	CO_2	45,479.14	72,914.82	5.00	5.00	7.10	0.04
1A3b Road Transportation	CH_4	225.74	556.65	5.00	194.85	194.90	0.00
1A3b Road Transportation	N_2O	677.82	964.31	5.00	202.50	202.60	0.01
1A3c Railways	CO_2	296.86	206.69	5.00	2.02	5.40	0.00
1A3c Railways	CH_4	0.42	0.38	5.00	60.10	60.30	0.00
1A3c Railways	N_2O	34.14	21.17	5.00	66.67	66.90	0.00
1A3d Water-borne Navigation	CO_2	186.21	612.51	5.00	1.50	5.20	0.00
1A3d Water-borne Navigation	CH_4	0.44	1.78	5.00	50.00	50.20	0.00
1A3d Water-borne Navigation	N_2O	1.5	4.47	5.00	140.00	140.10	0.00
1A4 Other Sectors							
1A4 Other sectors	CO_2	10,619.63	12,726.41	10.00	7.00	12.20	0.00
1A4 Other sectors	CH_4	28.06	1,122.75	10.00	150.00	150.30	0.00
1A4 Other sectors	N_2O	17.36	141.02	10.00	200.00	200.20	0.00
1B Fugitive Emissions							
1B1 Solid Fuels	CH_4	769.43	563	2.00	150.00	150.00	0.00
1B2a Oil	CO_2	0.01	0.12	5.00	500.00	500.00	0.00
1B2a Oil	CH_4	46.51	161.32	5.00	500.00	500.00	0.00
1B2b Natural Gas	CO_2	1.96	2.21	5.00	250.00	250.00	0.00
1B2b Natural Gas	CH_4	6,153.81	7,768.14	5.00	250.00	250.00	0.58
Total		**161,556.32**	**254,307.21**				**0.79**
				Percentage uncertainty in total inventory			**8.86**

Remark: 0.00 means less than 0.005

Emissions Trend by gas in the Energy Sector

Trends of CO_2 and CH_4, emissions increased from 2000 due to increasing consumption of fossil fuels in the Energy Industry (1A1), Manufacturing Industries (1A2) and Transport sectors (1A3). Then their trends stabilized during 2015-2019 mainly due to fossil fuels substitution with renewable energy in electricity generation, transportation and manufacturing. In the time series, Thailand's CO_2 emissions in the Energy sector reached the highest level at 244,993.29 ktCO_2eq in 2019, then decreased to 241,299.47 ktCO_2eq in 2022. CH_4 emissions in the Energy sector reached the highest level at 16,337.23 ktCO_2eq in 2013, then decreased to 10,865.53 ktCO_2eq in 2022. However, the trend of N_2O emissions kept increasing from 1,214.73 ktCO_2eq in 2000 to 2,142.21 ktCO_2eq in 2022 (Table 2-14). Figure 2-8 shows relative trends of CO_2, CH_4, and N_2O emissions in Energy sector when compared to the base year 2000.

Table 2-14: GHG emissions of source category in Energy sector by gas for 2000-2022

Year	Energy sector by gas			Total
	CO_2	CH_4	N_2O	
	ktCO_2eq			
2000	154,978.06	9,800.70	1,214.73	165,993.49
2001	163,016.28	9,591.12	1,179.47	173,786.87
2002	171,974.56	9,994.63	1,262.16	183,231.35
2003	180,913.34	9,932.60	1,355.52	192,201.46
2004	196,796.66	10,905.16	1,465.14	209,166.96
2005	200,512.20	11,327.63	1,507.29	213,347.12
2006	200,964.91	11,625.40	1,509.63	214,099.94
2007	206,795.17	12,161.45	1,554.56	220,511.18
2008	208,558.32	12,798.37	1,557.85	222,914.54
2009	208,459.50	12,426.66	1,620.22	222,506.38
2010	218,958.86	13,814.32	1,652.83	234,426.01
2011	215,382.26	14,110.63	1,684.40	231,177.29
2012	226,946.59	15,653.48	1,731.52	244,331.59
2013	219,630.13	16,337.23	1,828.25	237,795.61
2014	223,173.52	16,334.65	1,749.23	241,257.40
2015	226,231.16	15,313.08	1,792.66	243,336.90
2016	238,521.23	15,326.91	2,074.19	255,922.33
2017	239,543.87	14,941.98	2,100.57	256,586.42
2018	241,833.75	14,650.85	2,158.72	258,643.32
2019	244,993.29	14,842.71	2,246.80	262,082.80
2020	239,346.49	13,379.42	2,101.79	254,827.70
2021	227,393.04	12,581.97	1,946.77	241,921.78
2022	241,299.47	10,865.53	2,142.21	254,307.21
Change 2000-2022	55.70%	10.86%	76.35%	53.20%

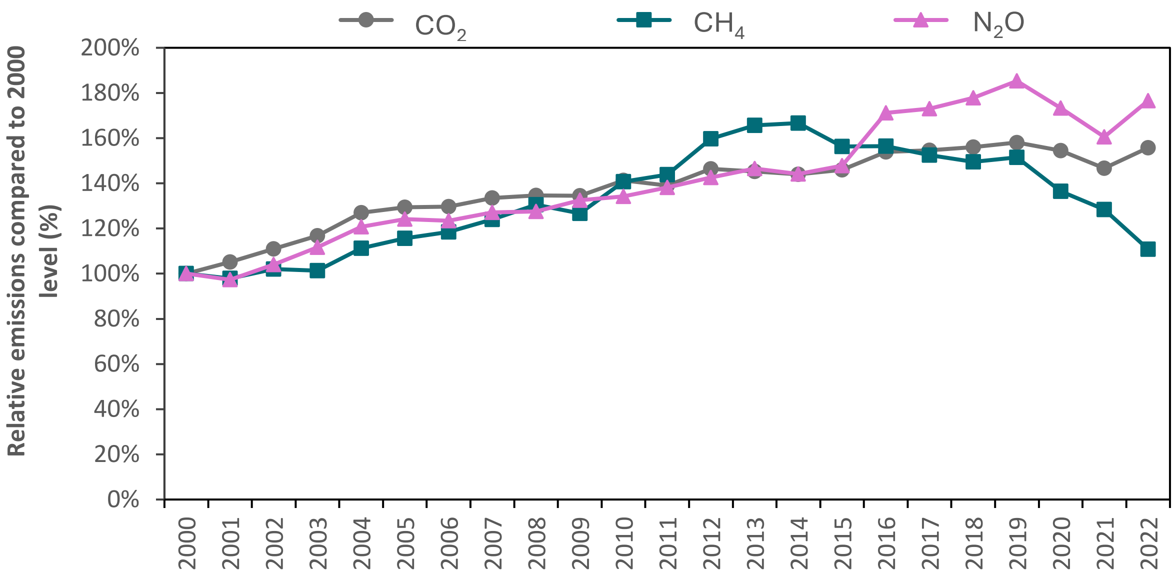


Figure 2-8: Relative trends of GHG emissions in Energy sector (base year is 2000)

Recalculations and Improvements in the Energy Sector

The inventory submission in this BTR follows Paragraph 37 of the MPGs (Decision 18/CMA.1 Annex). The 100-year time-horizon global warming potential (GWP) values from the IPCC Fifth Assessment Report (AR5) are used to convert GHGs other than CO_2 to CO_2eq, while the time-series national GHG emissions reported in the BUR4 employed 100-year global warming potential (GWP) from the IPCC Fourth Assessment Report (AR4). Thus, recalculations are done for each category in the Energy sector. Figure 2-9 shows comparison of time-series GHG emissions in the Energy sector for 2000-2022. Due to a higher value of GWP of methane in the IPCC-AR5 (28) compared to the IPCC-AR4 (25), GHG emissions in the Energy sector in this submission are slightly higher than the emissions in the BUR4 in a narrow range of 0.47%-0.65% throughout the time series. (Figure 2-10)

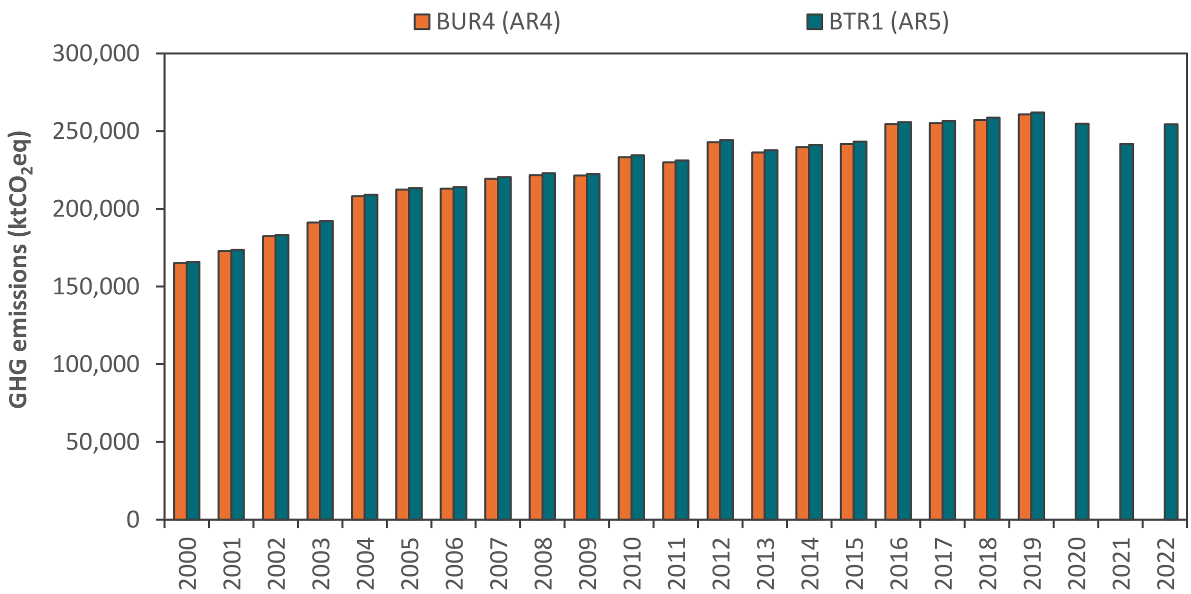


Figure 2-9: Comparison of GHG emissions in Energy sector between BUR4 and BTR1

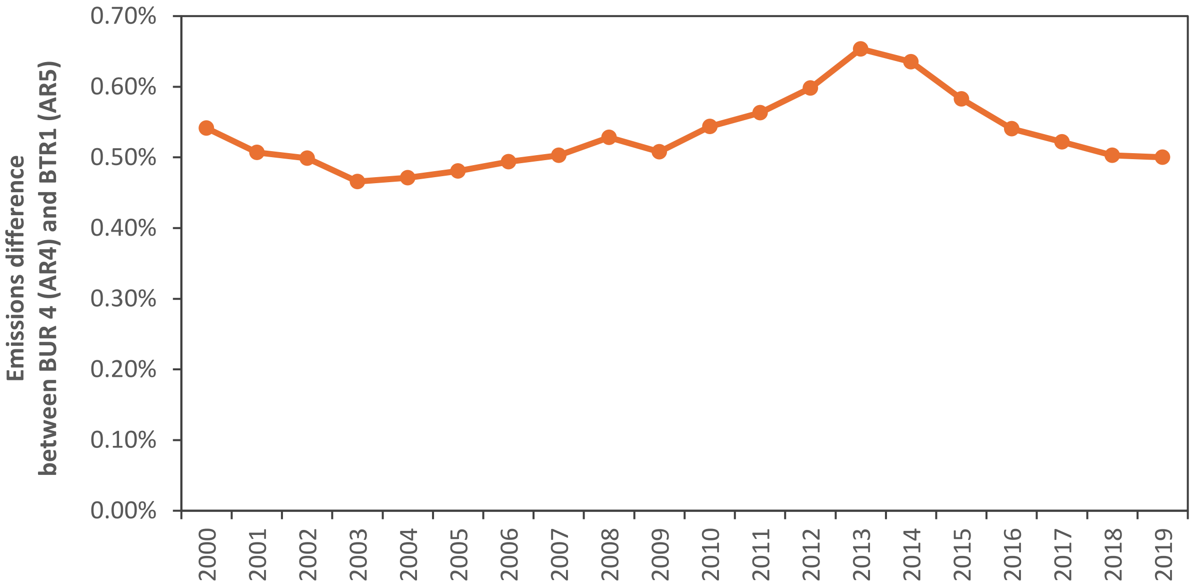


Figure 2-10: Percentage difference of emissions in Energy Sector in BTR1 compared to BUR4

Comparison of the Sectoral Approach with the Reference Approach

This section presents comparison of the national estimates of CO_2 emissions from fuel combustion with those obtained using the reference approach as contained in the IPCC Guidelines, in accordance with the MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex), paragraph 36.

The reference approach is to calculate the CO_2 emissions from combustion, using a country's energy supply data. The CO_2 emissions estimated by the reference approach are not included in the national total but used for verification purposes. The CO_2 emissions by the reference approach are estimated by using the 2006 IPCC Guidelines (Vol.2, Page 6.5, Eq.6.1)

EQUATION 6.1

CO_2 EMISSIONS FROM FUEL COMBUSTION USING THE REFERENCE APPROACH

$$CO_2\ Emissions = \sum_{all\ fuels}\left[\begin{array}{l}((Apparent\ Consumption_{fuel} \bullet Conv\ Factor_{fuel} \bullet CC_{fuel}) \bullet 10^{-3} \\ -Excluded\ Carbon_{fuel}) \bullet COF_{fuel} \bullet 44/12\end{array}\right]$$

Where:

CO_2 Emissions	=	CO_2 emissions ($GgCO_2$)
Apparent Consumption	=	production + imports – exports – international bunkers – stock change
Conv Factor (conversion factor)	=	conversion factor for the fuel to energy units (TJ) on a net calorific value basis
CC	=	carbon content (tonne C/TJ) Note that tonne C/TJ is identical to kg C/GJ
Excluded Carbon	=	carbon in feedstocks and non-energy use excluded from fuel combustion emissions (Gg C)

The reference approach outputs were compared to the sectoral emissions for the period 2000 to 2022 and the CO_2 emissions were always higher using the reference approach. In this BTR, the differences in CO_2 emissions using the reference and sectoral approach were 23.92%, 14.79%, 22.67% 21.41% 20.24% 21.23% and 21.57% for the years 2016, 2017, 2018, 2019, 2020, 2021 and 2022, respectively. The major differences were seen in the liquid and gaseous fuels, where consumption was consistently higher with the reference approach. Allocation of liquid and gaseous fuels between energy use and non-energy uses, as well as use for synthetic fuels production, remains one of the key drivers of the differences observed between the two datasets.

Energy Industries (1A1)

Category Description

This section provides the estimation methods for CO_2, CH_4 and N_2O emissions from Energy Industries (1A1) in Thailand, which includes Main Activity Electricity and Heat Production (1A1a) and Petroleum Refining (1A1b) (see Figure 2-11).

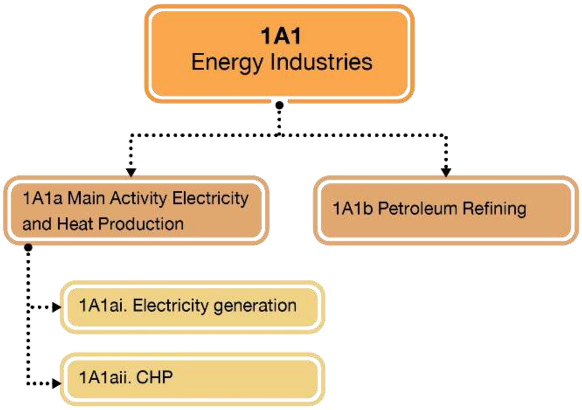


Figure 2-11: Emissions sources of Energy Industries (1A1) in Thailand

Estimation Method

The CO_2, CH_4 and N_2O emissions were calculated by using Tier 1 methods in accordance with the decision tree of the 2006 IPCC Guidelines (Vol. 2, Page 2.15, Fig. 2.1). For the Tier 1 approach, Equations 2.1 and 2.2 in the 2006 IPCC Guidelines (Vol. 2, Page 2.11, Eq. 2.1) were employed to estimate emissions from several fuels used in the Energy Industry (1A1).

EQUATION 2.1

GREENHOUSE GAS EMISSIONS FROM STATIONARY COMBUSTION

$$Emissions_{GHG,\, fuel} = Fuel\ \ Consumption_{fuel} \bullet Emission\ \ Factor_{GHG,\, fuel}$$

Where:

$Emissions_{GHG,fuel}$ = emissions of a given GHG by type of fuel (kg GHG)

$Fuel\ Consumption_{fuel}$ = amount of fuel combusted (TJ)

$Emission\ _{FactorGHG,fuel}$ = default emission factor of a given GHG by type of fuel (kg gas/TJ).

For CO_2, it includes the carbon oxidation factor, assumed to be 1.

To calculate the total emissions by gas from the source category, the emissions as calculated in Equation 2.1 in the 2006 IPCC Guidelines are summed over all fuels in Equation 2.2 (Vol. 2, Page 2.12, Eq. 2.2)

EQUATION 2.2
TOTAL EMISSIONS BY GREENHOUSE GAS

$$Emissions_{GHG} = \sum_{fuels} Emissions_{GHG,fuel}$$

Equations 2.1 and 2.2 in the 2006 IPCC Guidelines can be presented in the following equation:

$$EM = \sum_i (AD_i \times EF_i)$$

Where:
- EM = Emissions associated with Energy Industries
- EF_i = Emission factor of fuel consumption i
- AD_i = Fuel consumption of fuel type i
- i = Fuel type *(Coal, oil and gas etc.)*

Activity Data of Energy Industries (1A1)

Activity data for the energy industries are obtained from a collection of the official reports and documents from Energy Balance of Thailand and annual reports from the Department of Alternative Energy Development and Efficiency (DEDE) Ministry of Energy. Activity data of Main Activity Electricity (1A1a) for 2020, 2021 and 2022 after 2019, as reported in its BUR4, are presented in Table 2-15. Table 2-16 presents activity data of Petroleum Refining (1A1b) for 2020-2022.

Table 2-15: Activity data of Main Activity Electricity (1A1a) for 2020-2022

Type of fuels, Unit	2020	2021	2022	NCV (TJ/Unit)
Bituminous, kt	5,286	4,698	4,731	26.37
Briquettes, kt	1,240	1,102	1,146	26.37
Lignite, kt	13,223	14,245	13,659	10.47
Natural gas, MMscf.	1,023,106	1,022,759	901,908	1.02
Diesel, million liters	28.02	62.61	301.68	36.42
Biofuels, million liters	1.98	4.39	21.32	36.42
Fuel oil, million liters	29	98	26	39.77
Rice husk, kt	2,048	2,772	2,946	14.40
Bagasse, kt	23,352	24,026	26,010	7.53
Agricultural residue, kt	8,902	9,677	9,936	12.68
MSW, kt	1,249	1,490	5,080	4.86
Biogas, million m^3	1,054.20	1,161.46	1,230.47	20.93

Remarks: In 2020, an annual average of 6.60% biofuels blended with diesel. (Ministry of Energy)
In 2021, an annual average of 6.55% biofuels blended with diesel. (Ministry of Energy)

Table 2-16: Activity data of Petroleum Refining (1A1b) for 2020-2022.

Type of Fuels, Unit	2020	2021	2022	NCV (TJ/Unit)
Crude oil, million liters	57,915	57,248	59,926	36.33
Internal use of crude oil	6%	6%	6%	
Crude oil for energy, million liters	3,474.90	3,434.88	3,595.56	

Emission Factors of Energy Industries (1A1)

The emission factors employed in calculating greenhouse gas emissions in the Main Activity Electricity (1A1a) follow the default values of the 2006 IPCC Guidelines of National Greenhouse Gas Inventories for all fuel types. (Table 2-17) The emission factor from fuel consumed in Petroleum Refining (1A1b) is assumed to be in the range of 6 to 10 percent following 2006 IPCC Guidelines (Vol. 2, Fig. 2.3). The value of 6% is in agreement with the refinery industry.

Table 2-17: Emission factors of Main Activity Electricity (1A1a) for 2000-2022

Source/fuel	CO_2 (kg/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)	NO_x (kg/TJ)	CO (kg/TJ)	NMVOC (kg/TJ)
1A Fuel Combustion						
1A1 Energy Industries						
1A1a Public Electricity and Heat Production						
Fuel Oil	77,400	3.00	0.60	200.00	15.00	5.00
Diesel oil	74,100	3.00	0.60	200.00	15.00	5.00
Anthracite	98,300	1.00	1.50	300.00	20.00	5.00
Bituminous	94,600	1.00	1.50	300.00	20.00	5.00
Sub–bituminous	96,100	1.00	1.50	300.00	20.00	5.00
Lignite	101,000	1.00	1.50	300.00	20.00	5.00
Natural Gas	56,100	1.00	0.10	150.00	20.00	5.00
Biofuel (Biomass)	100,000	30.00	4.00	100.00	1000.00	50.00
Biodiesel	70,800	3.00	0.60	100.00	1000.00	50.00
Biogas	54,600	1.00	0.10	100.00	1000.00	50.00

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of Energy Industries, the uncertainties indicated in the 2006 IPCC Guidelines (-60% to +151% for CH_4 and -50% to +200% for N_2O) were adopted. Since the values in the annual energy reports of Ministry of Energy were used for the activity data, the default values in the 2006 IPCC Guidelines (-5% to +5%) were adopted for the uncertainty of activity data. Therefore, the uncertainty of the emissions from Energy Industries was estimated as -60% to +151% for CH_4 and -50% to +200% for N_2O.

Time-series Consistency

The data of Energy Industries given in the Energy Balance of Thailand of the Ministry of Energy are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand’s NDC, is reported. This flexibility is used in the light of domestic capacities, in accordance with the MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex), paragraph 57.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials.

The responsible agencies of the Ministry of Energy collected activity data and conducted their own QA/QC before sending to the inventory compilation at the Department of Climate Change and Environment (DCCE). In addition, at the DCCE a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

Emissions estimated for Energy Industries (1A1) follow the Tier 1 approach. Capacity building and supports are needed to adopt a higher tier method. Activity data at the disaggregated level and country-specific emission factors for Main Activity Electricity (1A1a) and Petroleum Refining (1A1b), in accordance with the good practice elaborated in the IPCC guidelines, are planned and proposed to implement before the next submission.

Estimated Emissions from Energy Industries (1A1)

Estimated CO_2, CH_4 and N_2O emissions from Energy Industries (1A1) for 2020-2022 are presented in Table 2-18. CO_2 emissions from Main Activity Electricity (1A1a) and Petroleum Refining (1A1b) in 2020, 2021 and 2022 are estimated at 89,066.58 and 9,253.62 $ktCO_2eq$, 88,611.57 and 9,147.05 $ktCO_2eq$, and 81,695.57 and 9,574.94 $ktCO_2eq$, respectively. Total GHG emissions from the Energy Industries (1A1) for 2020, 2021 and 2022 are estimated at 99,158.67, 98,643.67 and 92,222.65 $ktCO_2eq$, respectively.

Table 2-18: CO_2, CH_4 and N_2O emissions from Energy Industries (1A1) for 2020-2022

2020				
Category	**CO_2 ($ktCO_2eq$)**	**CH_4 ($ktCO_2eq$)**	**N_2O ($ktCO_2eq$)**	**Total ($ktCO_2eq$)**
1A1a	89,066.58	311.11	495.77	89,873.46
1A1b	9,253.62	10.60	20.07	9,284.30
2021				
Category	**CO_2 ($ktCO_2eq$)**	**CH_4 ($ktCO_2eq$)**	**N_2O ($ktCO_2eq$)**	**Total ($ktCO_2eq$)**
1A1a	88,611.57	333.53	521.20	89,466.30
1A1b	9,147.05	10.48	19.84	9,177.37
2022				
Category	**CO_2 ($ktCO_2eq$)**	**CH_4 ($ktCO_2eq$)**	**N_2O ($ktCO_2eq$)**	**Total ($ktCO_2eq$)**
1A1a	81,695.57	362.60	557.81	82,615.97
1A1b	9,574.94	10.97	20.77	9,606.68

Trend of CO_2 Emission from Energy Industries (1A1)

Main Activity Electricity (1A1a) dominated in CO_2 emissions, accounting for 90.59%, 60.64% and 89.51% of total CO_2 emissions from Energy Industries (1A1) in 2020, 2021 and 2022, respectively. The time series of CO_2 emissions from electricity generation in Main Activity Electricity (1A1a) shows that emissions reached the highest level at 96,989.07 $ktCO_2eq$ in 2017. Then, emissions continuously decreased from 2018-2022 clearly demonstrating that the strong renewable electricity policy in Thailand results in decreasing CO_2 emissions in electricity generation. (Figure 2-12)

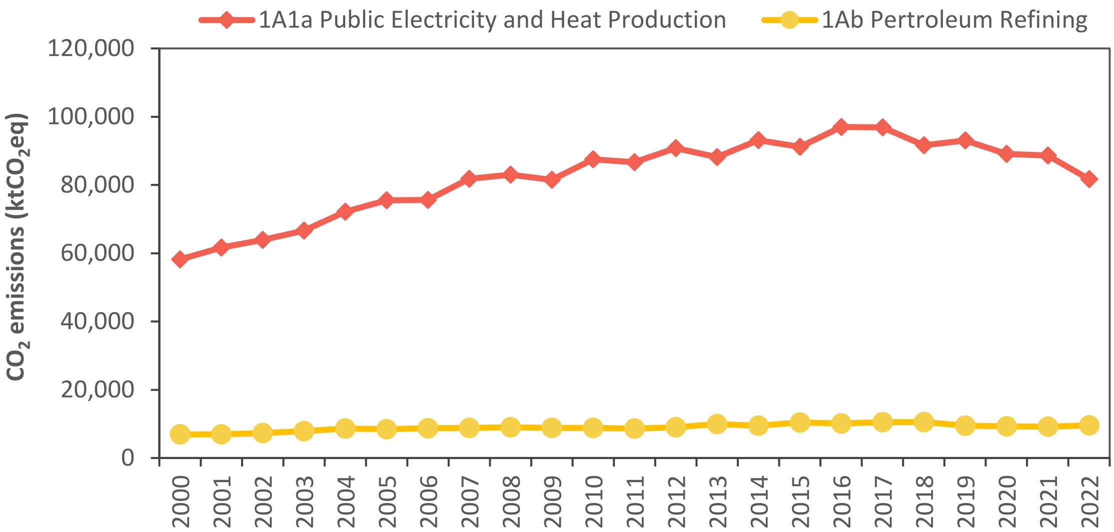


Figure 2-12: CO_2 emission from Energy Industries (1A1) for 2000-2022

Trends of CH_4 and N_2O Emissions from Energy Industries (1A1)

CH_4 and N_2O emissions from Energy Industries (1A1) for 2000, 2021 and 2022 after 2019, as reported in its BUR4, are presented in Table 2-18. The time series of these emissions shows increasing trends for both methane and nitrous oxide (Figure 2-13).

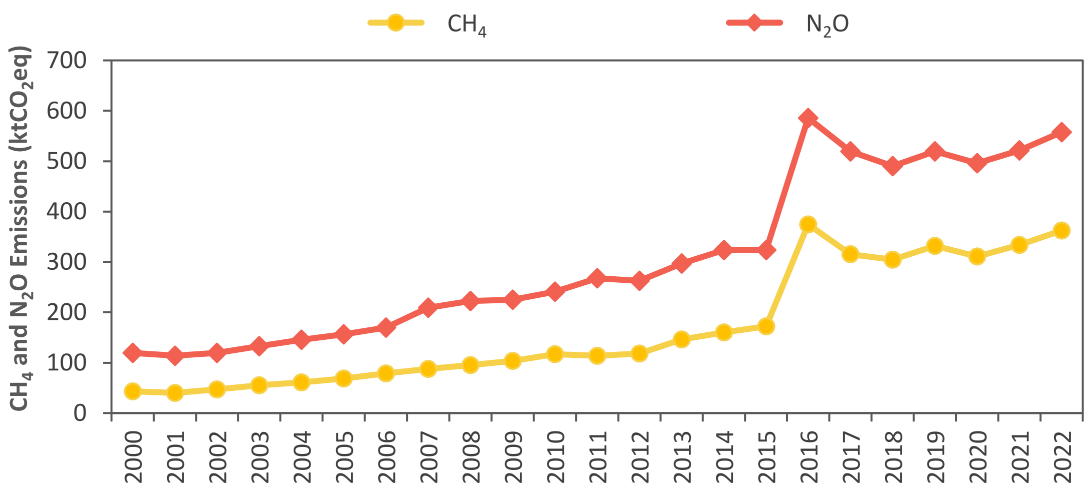


Figure 2-13: CH_4 and N_2O emissions from Energy Industries (1A1) for 2000-2022

Indirect Emissions from Energy Industries (1A1)

The indirect emissions including NO_x, CO, NMVOC, and SO_2 are estimated for 2020, 2021, and 2022, and presented in Table 2-19. NO_x and CO are the main contributors of the indirect emissions during 2020-2022. The Main Activity Electricity (1A1a) is the major source of indirect emissions in Energy Industries (1A1). The time-series NO_x emissions show a decreasing trend after 2016 while the time-series CO emissions show an increasing trend (Figure 2-14). The trend of the non-methane volatile organic compounds (NMVOC) in time- series slightly increases, but decreases for SO_2 due to a lower share of coal used in Energy Industries (1A1). The indirect emissions from Petroleum Refining (1A1b) and their trends are presented in Figure 2-15.

Table 2-19: Indirect emissions from Energy Industries (1A1) for 2020-2022

2020				
Category	**NO_x (kt)**	**CO (kt)**	**NMVOC (kt)**	**SO_2 (kt))**
1A1a	284.78	373.46	24.10	8.13
1A1b	25.25	1.89	0.63	0
2021				
Category	**NO_x (kt)**	**CO (kt)**	**NMVOC (kt)**	**SO_2 (kt))**
1A1a	285.88	402.09	25.51	50.25
1A1b	24.96	1.87	0.62	0
2022				
Category	**NO_x (kt)**	**CO (kt)**	**NMVOC (kt)**	**SO_2 (kt))**
1A1a	271.38	439.26	26.89	8.71
1A1b	26.13	1.96	0.65	0

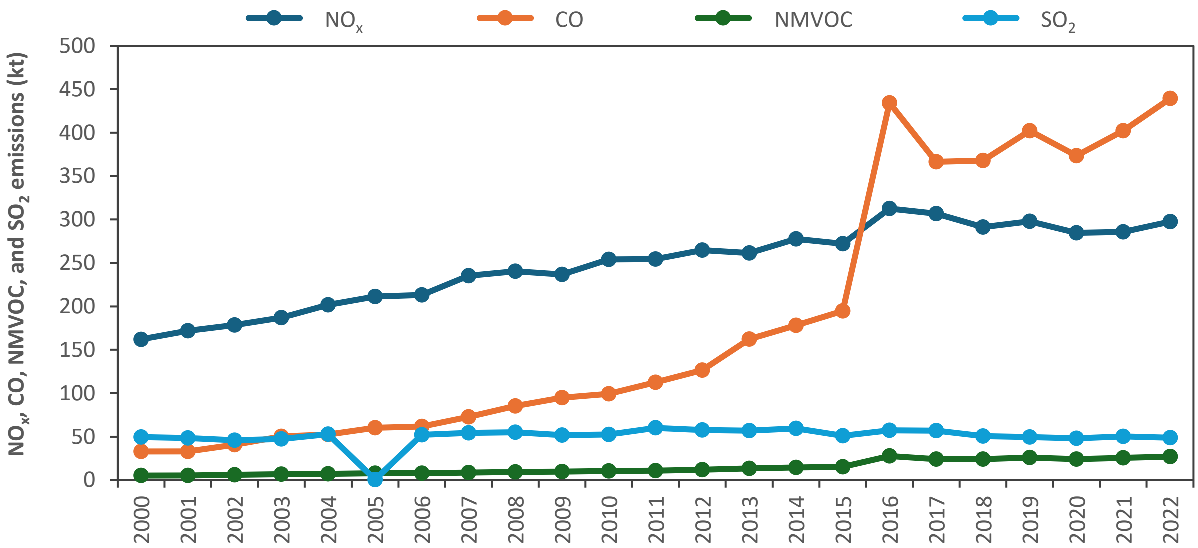


Figure 2-14: Indirect Emissions from Main Activity Electricity (1A1a) for 2000-2022

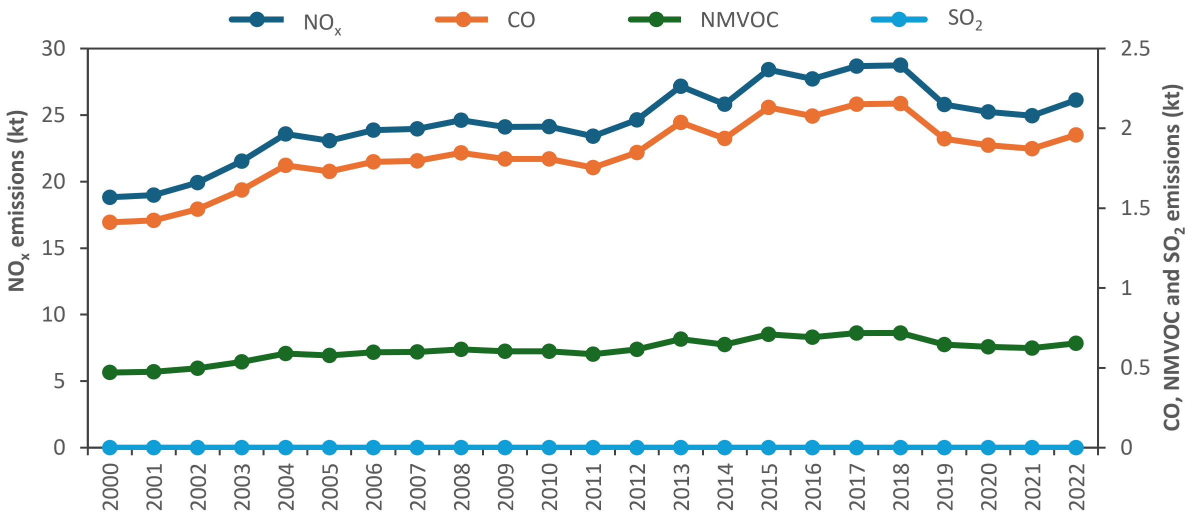


Figure 2-15: Indirect Emissions from Petroleum Refining (1A1b) for 2000-2022

Manufacturing Industries and Construction (1A2)

Category Description

This section provides the estimation methods for CO_2, CH_4 and N_2O emissions from Manufacturing Industries and Construction (1A2) in Thailand, which includes Iron and Steel (1A2a), Non-Ferrous Metals (1A2b), Chemicals (1A2c), Pulp, Paper and Print (1A2d), Food Processing, Beverages and Tobacco (1A2e), Non-Metallic Minerals (1A2f), Mining (excluding fuels) and Quarrying (1A2i), Wood and Wood Products (1A2j), Construction (1A2k), Textile and Leather (1A2l), and Non-specified Industry (1A2m) (see Figure 2-16).

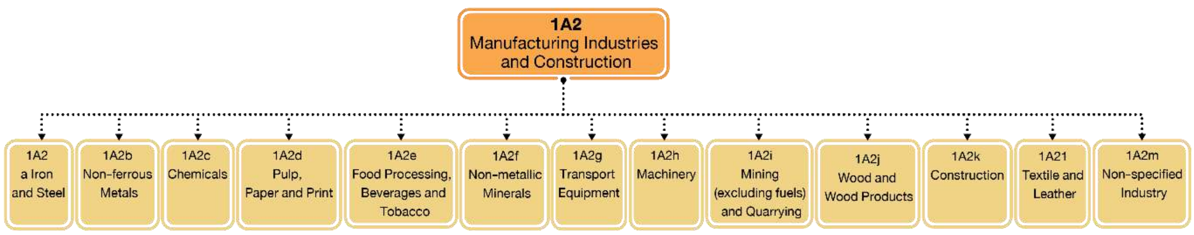


Figure 2-16: Emissions sources of Manufacturing Industries and Construction (1A2)

Estimation Method

The CO_2, CH_4 and N_2O emissions were calculated by using the Tier 1 method in accordance with the decision tree of the 2006 IPCC Guidelines (Vol. 2, page 2.15, Fig. 2.1). The equation used in estimation of emissions is as follows:

$$EM = \sum_i (AD_i \times EF_i)$$

Where: *EM* = Emissions associated with Manufacturing Industries (1A2)

EF_i = Emission factor of fuel consumption *i*

AD_i = Fuel consumption of fuel type *i*

i = Fuel type *(Coal, oil and gas etc.)*

Activity Data of Manufacturing Industries and Construction (1A2)

The aggregated activity data are employed for Manufacturing Industries and Construction (1A2). Activity data for the Manufacturing Industries and Construction are obtained from a collection of the official reports and documents from Thailand Energy Efficiency Situation, and from annual reports from the Department of Alternative Energy Development and Efficiency (DEDE) Ministry of Energy. Table 2-20 presents activity data of Manufacturing Industries and Construction (1A2) for 2020, 2021 and 2022 after 2019, as reported in its BUR4. The proportions of biofuels blended with diesel and gasoline in each reporting year are obtained from the Department of Energy Business. The net calorific values (NCVs) of each fuel are obtained from annual reports of the Ministry of Energy.

Table 2-20: Activity data in Manufacturing Industries and Construction (1A2) for 2020-2022

Type of fuels, Unit	2020	2021	2022	NCV (TJ/Unit)
Anthracite, kt	57	44	59	31.40
Bituminous, kt	1,503	1,194	1,548	26.37
Lignite, kt	204	278	398	10.47
Briquettes, kt	10,999	8,702	11,506	26.37
Coke, kt	75	55	72	27.63
Gasoline, million liters	16.40	22.70	22.70	31.48
Ethanol, million liters	1.60	2.30	2.30	21.54
Kerosene, million liters	4	6	5	34.53
Diesel, million liters	2,194.90	2,736.22	2,534.88	36.42
Biofuels, million liters	155.10	191.78	179.12	36.42
Fuel oil, million liters	694	728	696	39.77
LPG, million liters	1,136	1,264	1,373	26.62
Natural gas, MMscf.	153,989	171,259	284,046	1.02
MSW, kt	1,009	1,250	1,523	4.86
Fuel wood, kt	671	464	587	15.99
Rice husk, kt	1,212	838	1,033	14.40
Bagasse, kt	17,377	12,914	15,892	7.53
Agricultural residue, kt	7,118	5,431	6,697	12.68
Biogas, million m^3	1,386.78	1,388.48	1,389.81	20.93

Remarks: In 2020, an annual average of 6.60% biofuels blended with diesel. (Ministry of Energy)
In 2021, an annual average of 6.55% biofuels blended with diesel. (Ministry of Energy)

Emission Factors of Manufacturing Industries and Construction (1A2)

The emission factors employed in calculating greenhouse gas emissions in the Manufacturing Industries and Construction (1A2) follow the default values of the 2006 IPCC Guidelines of National Greenhouse Gas Inventories for all fuel types. (Table 2-21) These emission factors are used in estimation of emissions from Manufacturing Industries and Construction (1A2).

Table 2-21: Emission factors of Manufacturing Industries and Construction (1A2) for 2000-2022

Source/fuel	CO_2 (kg/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)	NO_x (kg/TJ)	CO (kg/TJ)	NMVOC (kg/TJ)
1A Fuel Combustion						
1A2 Manufacturing Industries and Construction						
Anthracite	98,300	10.0	1.50	300.00	150.0	20.0
Bituminous	94,600	10.0	1.50	300.00	150.0	20.0
Sub–bituminous	96,100	10.0	1.50	300.00	150.0	20.0
Lignite	101,000	10.0	1.50	300.00	150.0	20.0
Coke	94,600	10.0	1.50	300.00	150.0	20.0
Gasoline	69,300	3.00	0.60	200.00	10.00	5.00
Kerosene	71,900	3.00	0.60	200.00	10.00	5.00
Diesel oil	74,100	3.00	0.60	200.00	10.00	5.00
Fuel Oil	77,400	3.00	0.60	200.00	10.00	5.00
LPG	63,100	1.00	0.10	200.00	20.00	5.00
Natural Gas	56,100	1.00	0.10	150.00	30.00	5.00
MSW	91,700	30.0	4.0	100.0	4,000.0	50.0
Fuel wood	112,000	30.0	4.0	100.0	2,000.0	50.0
Rice husk	100,000	30.0	4.0	100.0	4,000.0	50.0
Bagasse	100,000	30.0	4.0	100.0	4,000.0	50.0
Agricultural residue	100,000	30.0	4.0	100.0	4,000.0	50.0
Biogas	54,600	1.0	4.0	0.1	4,000.0	50.0

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of manufacturing industries and construction, the uncertainties indicated in the 2006 IPCC Guidelines (-60% to +151% for CH_4 and -50% to +200% for N_2O) were adopted. Since the values in the annual energy reports of Ministry of Energy were used for the activity data, the default values in the 2006 IPCC Guidelines (-5% to +5%) were adopted for the uncertainty of activity data. Therefore, the uncertainty of the emissions from manufacturing industries and construction was estimated as -60% to +151% for CH_4 and -50% to +200% for N_2O.

Time series Consistency

The same emission factors were used throughout the time series. The data given in the Thailand Energy Efficiency Situation of the Department of Alternative Energy Development and Efficiency (DEDE) Ministry of Energy were used as activity data consistently throughout the timeseries.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials at the Ministry of Energy and the inventory compilation office at DCCE. Then, QA procedures have been conducted at DCCE with a group of small experts, and a sub-committee at the Ministry of Natural Resources and Environment.

Category-specific Planned Improvements

Emissions estimated for Manufacturing Industries and Construction (1A2) follow the Tier 1 approach and default emission factors. Capacity building and support are needed to adopt a higher tier method. Activity data at the disaggregated level and country-specific emission factors of Tier 2 for manufacturing industries and construction, in accordance with the good practice elaborated in the IPCC Guidelines, are planned and proposed to implement before the next submission.

Estimated Emissions in Manufacturing Industries and Construction (1A2)

CO_2, CH_4 and N_2O Emissions from Manufacturing Industries and Construction (1A2)

The aggregated activity data of Manufacturing Industries and Construction (1A2) were used in estimation of CO_2, CH_4 and N_2O emissions for 2020, 2021, and 2022 after 2019, as reported in its BUR4 (Table 2-22). Total emissions from Manufacturing Industries and Construction (1A2) were found to be increasing except the year 2021due to COVID-19 pandemic. CO_2 was the main gas (98.73%) of total GHG emissions from Manufacturing Industries and Construction (1A2).

Table 2-22: CO_2, CH_4 and N_2O emissions from Manufacturing Industries and Construction (1A2) for 2020-2022

Year	CO_2 (ktCO_2eq)	CH_4 (ktCO_2eq)	N_2O (ktCO_2eq)	Total (ktCO_2eq)
2020	53,206.69	325.12	430.47	53,962.28
2021	47,538.18	253.66	336.93	48,128.77
2022	61,840.83	317.59	419.86	62,578.28

Indirect Emissions from Manufacturing Industries and Construction (1A2)

The indirect emissions including NO_x, CO, non-methane volatile organic compounds (NMVOC), and SO_2 were estimated for 2020, 2021, and 2022, and presented in Table 2-23. NO_x and CO were the main contributors of the indirect emissions during 2020-2022.

Table 2-23: Indirect emissions from Manufacturing Industries and Construction (1A2) for 2020-2022

Year	NO_x (kt)	CO (kt)	NMVOC (kt)	SO_2 (kt))
2020	185.04	1,168.09	22.47	432.93
2021	160.94	914.97	18.06	357.34
2022	207.15	1,105.68	22.55	452.55

Trend of CO_2 Emission in Manufacturing Industries and Construction (1A2)

The time series of CO_2 emissions in Manufacturing Industries and Construction (1A2) reveals increasing trends with fluctuation during 2006-2021, and reaches the highest level of emissions in 2022 at 61,840.83 $ktCO_2eq$. (Figure 2-17)

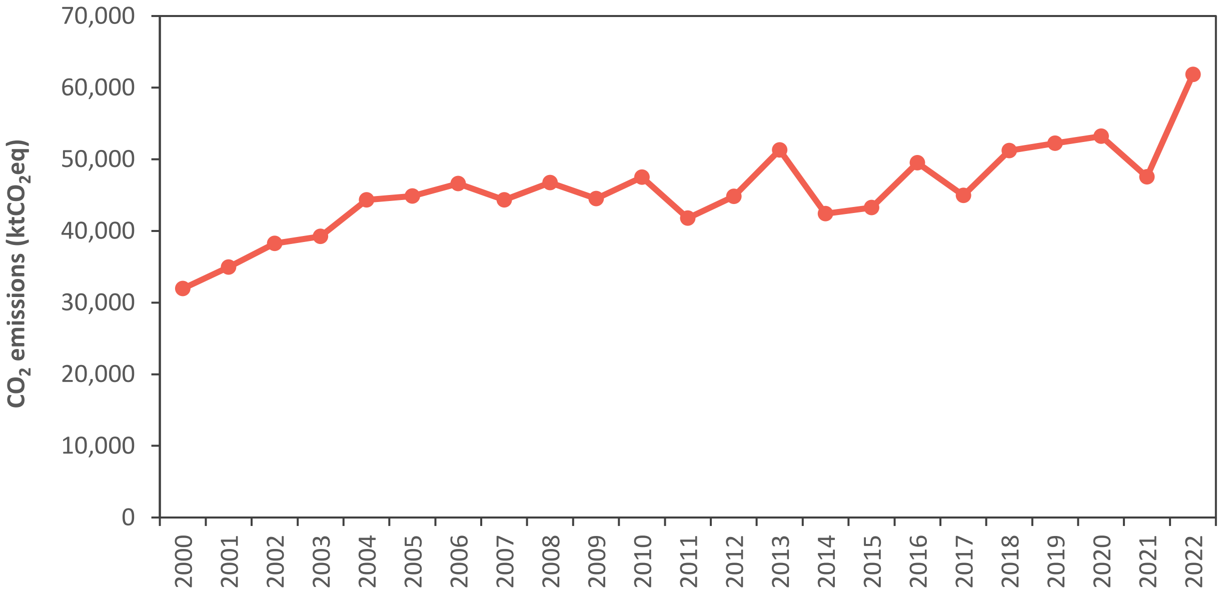


Figure 2-17: CO_2 emission in Manufacturing Industries and Construction (1A2) for 2000-2022

Trends of CH_4 and N_2O Emissions in Manufacturing Industries and Construction (1A2)

The time series of CH_4 and N_2O Emissions in Manufacturing Industries and Construction (1A2) shows increasing trends. CH_4 and N_2O emissions reach the highest levels at 383.44 and 504.01 $ktCO_2eq$ in 2019. Then, the trends of CH_4 and N_2O emissions dropped to 253.66 and 336.93 $ktCO_2eq$ in 2021, respectively, due to the COVID-19 pandemic. (Figure 2-18)

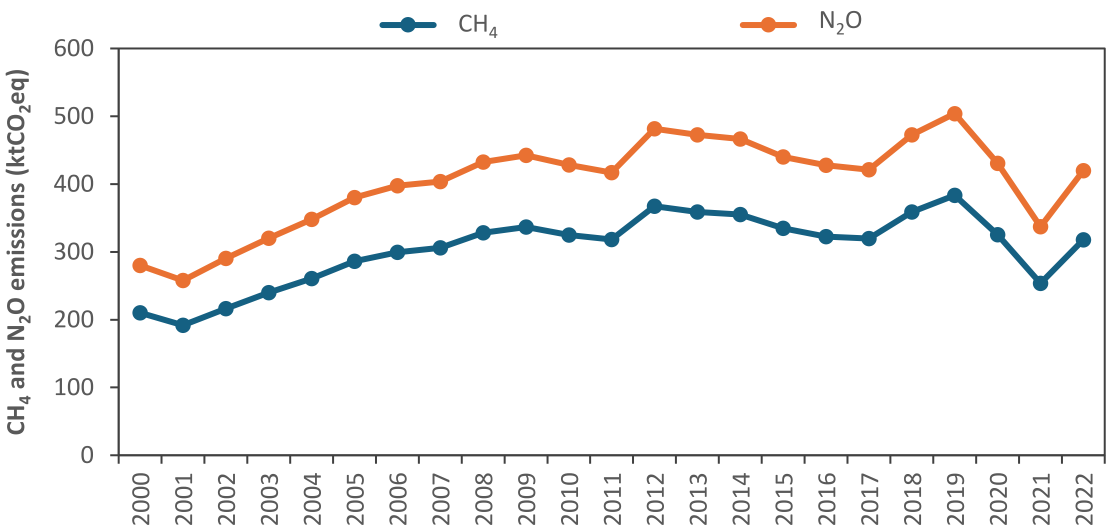


Figure 2-18: CH_4 and N_2O emissions in Manufacturing Industries and Construction (1A2) for 2000-2022

Transport (1A3)

Category Description

This section provides the estimation methods for CO_2, CH_4 and N_2O emissions from Transport (1A3) in Thailand, which includes civil aviation, road transportation, railway, and water-borne navigation (see Figure 2-19).

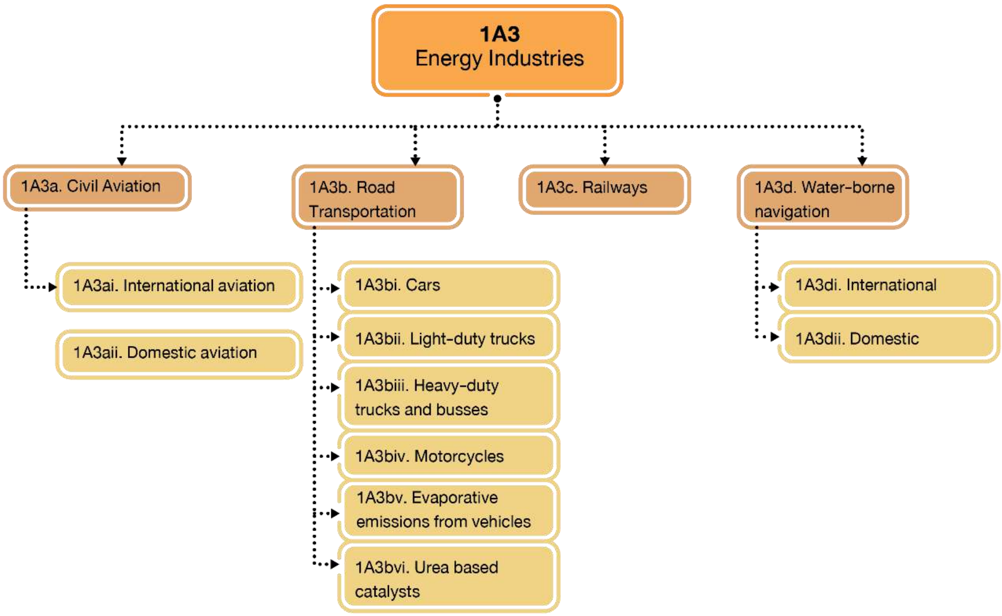


Figure 2-19: Emissions sources of Transport (1A3) in Thailand

Estimation Method

The CO_2, CH_4 and N_2O emissions were calculated by using the Tier 1 method in accordance with the decision tree of the 2006 IPCC Guidelines (Vol.2). The decision trees in Vol. 2, Page 3.11, Fig.3.2.1 were applied to estimate CO_2 emission, and Vol. 2, Page 3.14, Fig.3.2.3 was applied to estimate CH_4 and N_2O emissions from road transport. The decision trees in Vol. 2, Page 3.40, Fig.3.4.1 were applied to estimate CO_2 emission, and Vol. 2, Page 3.41, Fig.3.4.2 was applied to estimate CH_4 and N_2O emissions from railways. The decision tree in Vol. 2, Page 3.49, Fig.3.5.1 was applied to estimate CO_2, CH_4 and N_2O emissions from water-borne navigation. Finally, the decision tree in Vol. 2, Page 3.60, Fig.3.6.1 was applied to estimate CO_2, CH_4 and N_2O emissions from civil aviation. Aggregated activity data were used for estimation of emissions by using IPCC default emission factors in the following equation:

$$EM = \sum_i (AD_i \times EF_i)$$

Where: EM = Emissions associated with transport activity (1A3)

EF_i = Emission factor of fuel consumption i

AD_i = Fuel consumption of fuel type i

i = Fuel type

Activity Data of Transport (1A3)

Activity data for the Transport sector were obtained from a collection of the official reports and documents from Energy Balance of Thailand and annual reports from the Department of Alternative Energy Development and Efficiency (DEDE), State Railway of Thailand (SRT), and the Civil Aviation Authority of Thailand (CAAT) (Table 2-24). The information obtained was analyzed, examined, and calculated for the greenhouse gas emissions. The international aviation and marine bunker fuel emissions are reported as two separate entries (Table 2-25). Total annual fuels consumption for domestic aviation was provided by CAAT (Table 2-26). Estimated emissions from international aviation were not included in national totals but reported distinctly, in accordance with the MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex), paragraph 53. Activity data of Road Transport (1A3b) for 2020-2022 are presented in Table 2-27. Activity data of Railways Transport (1A3c) for 2020-2022 are presented in Table 2-28. Activity data of Water-borne Navigation (1A3di) and (1A3dii) for 2020-2022 are presented in Tables 2-29 and 2-30.

Table 2-24: Sources of activity data for estimation of emissions in Transport (1A3)

Transport (1A3)	Sources of activity data
International Aviation (1A3ai)	Energy Balance of Thailand, Ministry of Energy
Domestic Aviation (1A3aii)	Civil Aviation Authority of Thailand (CAAT)
Road (1A3b)	Energy Balance of Thailand, Ministry of Energy
Railways (1A3c)	State Railway of Thailand (SRT)
International Water-borne Navigation (1A3di)	Energy Balance of Thailand, Ministry of Energy
Domestic Water-borne Navigation(1A3dii)	Energy Balance of Thailand, Ministry of Energy Marine Department, Ministry of Transport

Table 2-25: Activity data of International Aviation (1A3ai) for 2020-2022

Type of fuels, Unit	2020	2021	2022	NCV (TJ/Unit)
Jet Fuel, million liters	2,162	1,412	2,664	34.53

Table 2-26: Activity data of Domestic Aviation (1A3aii) for 2020-2022

Type of fuels, Unit	2020	2021	2022	NCV (TJ/Unit)
Jet Fuel, million liters	761.10	292.86	698.85	34.53

Table 2-27: Activity data of Road Transport (1A3b) for 2020-2022

Type of fuels, Unit	2020	2021	2022	NCV (TJ/Unit)
NGV (dry basis), MMscf.	50,809	40,982	44,619	1.02
LPG, million liters	1,386	1,177	1,479	26.62
Gasoline, million liters	9,963.20	9,111.10	9,475.50	31.48
Ethanol, million liters	1,615.80	1,458.90	1,506.50	21.54
Diesel, million liters	16,765.30	16,165.92	17,491.95	36.42
Biofuels, million liters	1,184.70	1,133.08	1,236.05	36.42

Table 2-28: Activity data of Railways Transport (1A3c) for 2020-2022

Type of fuels, Unit	2020	2021	2022	NCV (TJ/Unit)
HSD, million liters	76.59	73.83	76.59	36.42
Biodiesel, million liters	5.41	5.17	5.41	36.42

Note: HSD stands for High Speed Diesel.

Table 2-29: Activity data of International Water-borne Navigation (1A3di) for 2020-2022

Type of fuels, Unit	2020	2021	2022	NCV (TJ/Unit)
Fuel oil, million liters	1,052	1,311	1,658	36.42

Table 2-30: Activity data of Domestic Water-borne Navigation (1A3dii) for 2020-2022

Type of fuels, Unit	2020	2021	2022	NCV (TJ/Unit)
HSD, million liters	187.73	182.23	226.96	36.42
Biofuels, million liters	13.27	12.77	16.04	36.42

Note: HSD stands for High-Speed Diesel.

Emission Factors of Transport (1A3)

The IPCC default emission factors were used in estimation of emissions in the Transport (1A3). The emission factors of Transport (1A3) are presented in Table 2-31.

Table 2-31: Emission factors of Transport (1A3) for 2000-2022

Source/fuel	CO_2 (kg/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)	NO_x (kg/TJ)	CO (kg/TJ)	NMVOC (kg/TJ)
1A3ai International Aviation						
Jet fuel	71,500	0.5	2			
1A3aii Domestic Aviation						
Jet fuel	71,500	0.5	2			
1A3b Road transport						
Natural Gas	56,100	92	3			
LPG	63,100	62	0.2			
Gasoline	69,300	33	3.2			
Ethanol	70,800	10	0.6			
Diesel oil	74,100	3.9	3.9			
Biodiesel	70,800	10	0.6			

Source/fuel	CO_2 (kg/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)	NO_x (kg/TJ)	CO (kg/TJ)	NMVOC (kg/TJ)
1A3c Railways						
Diesel oil	74,100	4.15	28.6			
Biodiesel	70,800	10	0.6			

Source/fuel	CO_2 (kg/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)	NO_x (kg/TJ)	CO (kg/TJ)	NMVOC (kg/TJ)
1A3di International Water-borne Navigation						
Fuel Oil	77,400	7	2			
1A3dii Domestic Water-borne Navigation						
Diesel oil	74,100	7	2			
Biodiesel	70,800	10	0.6			

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of transport, the uncertainties indicated in the 2006 IPCC Guidelines (-60% to +151% for CH_4 and -50% to +200% for N_2O) were adopted. Since the values in the annual reports of relevant agencies were used for the activity data, the default values in the 2006 IPCC Guidelines (-5% to +5%) were adopted for the uncertainty of activity data. Therefore, the uncertainty of the emissions from manufacturing industries and construction was estimated as -60% to +151% for CH_4 and -50% to +200% for N_2O.

Time-series Consistency

The same emission factors are used throughout the time series. The data given in the Energy Balance of Thailand are used as activity data for road railways and water-borne navigation consistently throughout the time series. The activity data for domestic aviation has been provided by the Civil Aviation Authority of Thailand (CAAT) since 2017, and verified with the Energy Balance of the Ministry of Energy consistently throughout the time series.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials. The responsible agencies collected activity data and conducted their own QA/QC before sending the data to the inventory compilation office at the Department of Climate Change and Environment (DCCE). In addition, at the DCCE a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

Emissions estimated for Transport (1A3) follow the Tier 1 approach using aggregated activity data. Capacity building and support are needed to adopt a higher tier method. Activity data at the disaggregated level and country-specific emission factors of tier 2 for Transport, in accordance with the good practice elaborated in the IPCC guidelines, are planned and proposed to implement before the next submission.

Estimated Emissions from Transport (1A3)

Table 2-32 presents estimated CO_2, CH_4 and N_2O emissions of Domestic aviation (1A3aii), Road (1A3b), Railways (1A3c), and Domestic navigation (1A3dii) for 2020. Tables 2-33 and 2-34 present estimated emissions for 2021 and 2022, respectively. It is found that total GHG emissions in Transport (1A3) dropped in 2021 due to the COVID-19 pandemic. Then, total GHG emissions in Transport (1A3) increased in 2022.

Table 2-32: Emissions in Transport (1A3) for 2020

Transport (1A3)	CO_2 ($ktCO_2eq$)	CH_4 ($ktCO_2eq$)	N_2O ($ktCO_2eq$)	Total ($ktCO_2eq$)
Domestic aviation (1A3aii)	1,879.08	0.37	13.93	1,893.37
Road (1A3b)	72,215.73	580.36	955.12	73,751.21
Railways (1A3c)	206.69	0.38	21.17	228.24
Domestic navigation (1A3dii)	506.64	1.48	3.70	511.82
Total (excluding International)	**74,808.14**	**582.58**	**993.92**	**76,384.64**

Table 2-33: Emissions in Transport (1A3) for 2021

Transport (1A3)	CO_2 ($ktCO_2eq$)	CH_4 ($ktCO_2eq$)	N_2O ($ktCO_2eq$)	Total ($ktCO_2eq$)
Domestic aviation (1A3aii)	723.04	0.14	5.36	728.54
Road (1A3b)	67,825.86	515.80	900.46	69,242.13
Railways (1A3c)	199.23	0.37	20.41	220.01
Domestic navigation (1A3dii)	491.78	1.43	3.59	496.80
Total (excluding International)	**69,239.92**	**517.74**	**929.82**	**70,687.48**

Table 2-34: Emissions in Transport (1A3) for 2022

Transport (1A3)	CO_2 ($ktCO_2eq$)	CH_4 ($ktCO_2eq$)	N_2O ($ktCO_2eq$)	Total ($ktCO_2eq$)
Domestic aviation (1A3aii)	1,725.39	0.34	12.79	1,738.51
Road (1A3b)	72,914.82	556.65	964.31	74,435.79
Railways (1A3c)	206.69	0.38	21.17	228.24
Domestic navigation (1A3dii)	612.51	1.78	4.47	618.76
Total (excluding International)	**75,459.41**	**559.16**	**1,002.75**	**77,021.31**

For indirect emissions, NO_x, CO NMVOC, and SO_2 were estimated for Domestic aviation (1A3aii), Road (1A3b), Railways (1A3c), and Domestic navigation (1A3dii). Tables 2-35, 2-36 and 2-37 present indirect emissions of Transport (1A3) by sources for 2000, 2021 and 2022, respectively. It was found that Road (1A3b) is the major sources of NO_x, CO NMVOC, and SO_2 emissions in Thailand.

Table 2-35: Indirect emissions in Transport (1A3) for 2020

Transport (1A3)	NO_X (kt)	CO (kt)	NMVOC (kt)	SO_2 (kt)
Domestic aviation (1A3aii)	7.88	2.63	1.31	NA
Road (1A3b)	729.89	3,155.21	593.43	9.28
Railways (1A3c)	3.35	2.79	0.56	NA
Domestic navigation (1A3dii)	10.26	6.84	1.37	NA
Total	**751.38**	**3,167.47**	**596.67**	**9.28**

Table 2-36: Indirect emissions in Transport (1A3) for 2021

Transport (1A3)	NO_X (kt)	CO (kt)	NMVOC (kt)	SO_2 (kt)
Domestic aviation (1A3aii)	3.03	1.01	0.51	NA
Road (1A3b)	686.98	2,912.56	548.75	8.75
Railways (1A3c)	3.23	2.69	0.54	NA
Domestic navigation (1A3dii)	9.96	6.64	1.33	NA
Total	**703.20**	**2,922.89**	**551.12**	**8.75**

Table 2-37: Indirect emissions in Transport (1A3) for 2022

Transport (1A3)	NO_X (kt)	CO (kt)	NMVOC (kt)	SO_2 (kt)
Domestic aviation (1A3aii)	7.24	2.41	1.21	NA
Road (1A3b)	739.55	3,057.32	575.68	9.32
Railways (1A3c)	3.35	2.79	0.56	NA
Domestic navigation (1A3dii)	12.40	8.27	1.65	NA
Total	**762.53**	**3,070.79**	**579.09**	**9.32**

Trend of CO_2 Emissions in Transport (1A3)

The time-series CO_2 emissions show an increasing trend. Road (1A3b) is the key contributor of CO_2 emissions in Transport (1A3). The proportion of CO_2 emissions of Domestic aviation (1A3aii) in the time series slightly increased from 2015 to 2020, and reached the highest level of 2,636.56 ktCO_2eq in 2018. The proportions of CO_2 emissions of Railways (1A3c) and Domestic navigation (1A3dii) in Transport (1A3) are relatively very small compared to Road (1A3b) (Figure 2-20).

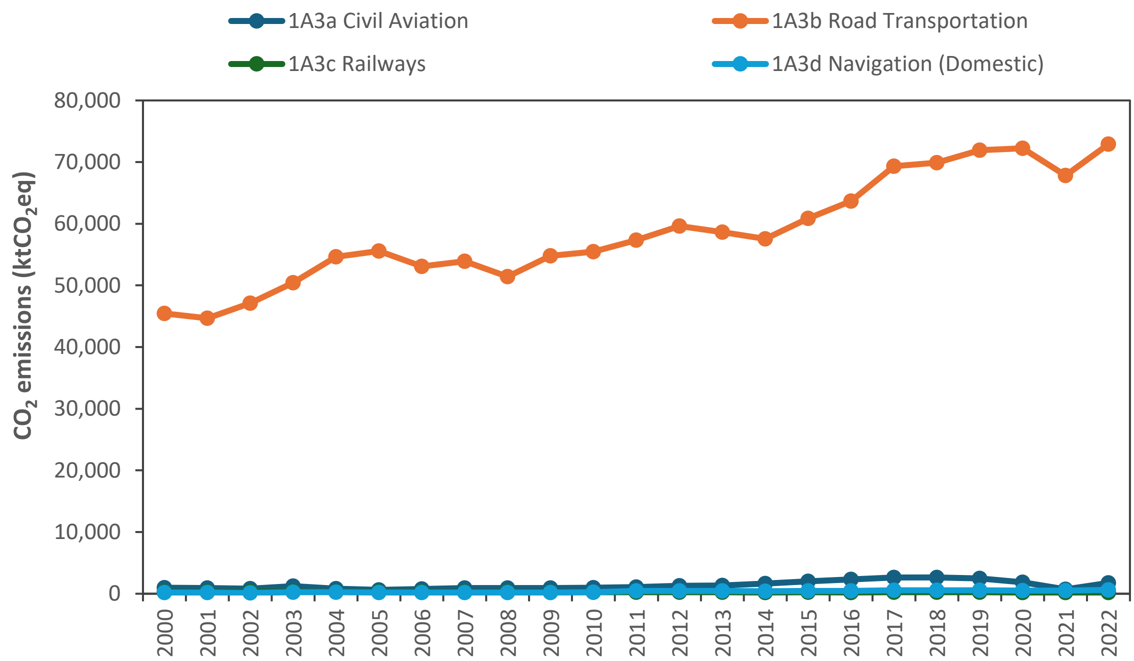


Figure 2-20: CO_2 emission in Transport (1A3) for 2000-2022

Trends of CH_4 and N_2O Emissions in Transport (1A3)

Trends of CH_4 and N_2O emissions in the time series increased from 2000 to 2022. While the trend of N_2O emissions increased with fluctuation in a small range, the trend of CH_4 emissions steadily increased from 2000 and reached the highest level at 743.96 $ktCO_2eq$ in 2014, and then CH_4 emissions steadily dropped to 517.74 $ktCO_2eq$ in 2021. (Figure 2-21).

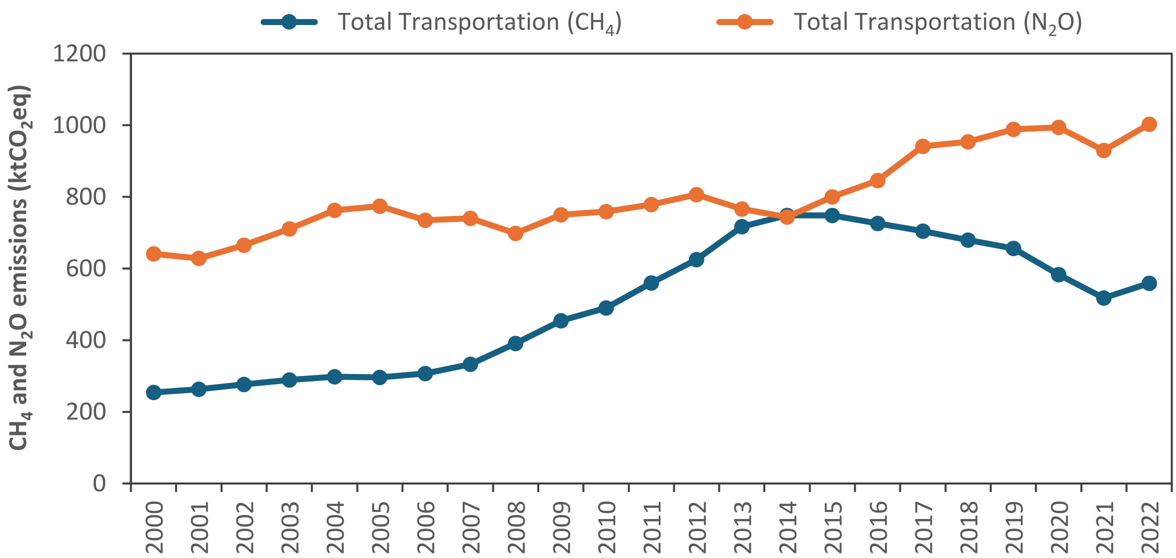


Figure 2-21: CH_4 and N_2O emissions in Transport (1A3) for 2000-2022

Other Sectors (1A4)

Category Description

This section provides the estimation methods for CO_2, CH_4 and N_2O emissions from Other Sectors (1A4) in Thailand. Emissions from sources were estimated from Commercial / Institutional (1A4a), Residential (1A4b), and Agriculture / Forestry / Fishing / Fish farms (1A4c). (Figure 2-22).

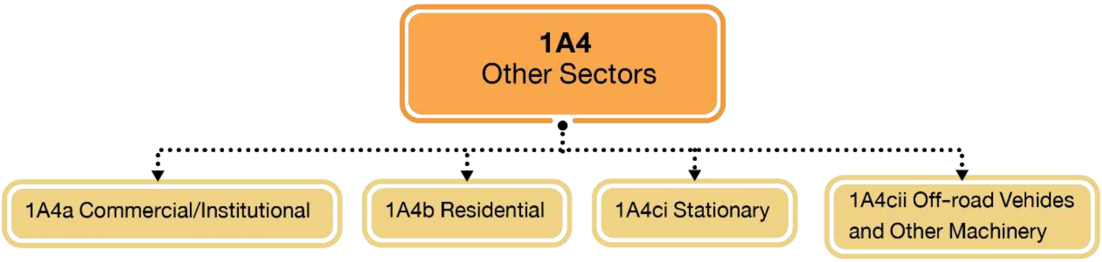


Figure 2-22: Emissions sources of Other Sectors (1A4) in Thailand

Estimation Method

The CO_2, CH_4 and N_2O emissions were calculated by using the Tier 1 method in accordance with the decision tree of the 2006 IPCC Guidelines (Vol.2). Emissions were estimated by using the aggregated activity data and IPCC default emission factors with the following equation:

$$EM = \sum_i (AD_i \times EF_i)$$

Where: EM = Emissions associated with activity
EF_i = Emission factor of fuel consumption i
AD_i = Fuel consumption of fuel type i
i = Fuel type

Activity Data of Other Sectors (1A4)

Activity data for the Other Sectors were obtained from a collection of the official reports and documents from Energy Balance of Thailand and annual reports from the Department of Alternative Energy Development and Efficiency (DEDE). The information obtained was analyzed, examined, and calculated for the greenhouse gas emissions Activity data for 2020, 2021 and 2022 after 2019, as presented in BUR4, are shown in Tables 2-38, 2-39 and 2-40, respectively. The net calorific values (NCVs) of fuels are provided in the annual reports of DEDE Ministry of Energy.

Table 2-38: Activity data of Commercial/Institution (1A4a) for 2020-2022

Type of fuels, Unit	2020	2021	2022	NCV (TJ/Unit)
LPG, million liters	869	924	944	26.62
Natural gas, MMscf	50	44	44	1.02

Table 2-39: Activity data of Residential (1A4b) for 2020-2022

Type of fuels, Unit	2020	2021	2022	NCV (TJ/Unit)
LPG, million liters	2,900	2,895	2,935	26.62
Fuel wood, kt	4,782	4,030	4,110	15.99
Rice husk, kt	569	957	491	14.40
Charcoal, kt	1,151	480	978	28.88
Agricultural residue, kt	3,369	2,887	2,948	12.68

Table 2-40: Activity data of Agriculture/Forestry/Fishing/Fish farms (1A4c) for 2020-2022

Type of fuels, Unit	2020	2021	2022	NCV (TJ/Unit)
Diesel, million liters	2,473.23	2,384.84	2,300.44	36.42
Biofuels, million liters	174.77	167.16	162.56	36.42

Emission Factors of Other Sectors (1A4)

The default emission factors of each GHG gas for each fuel type in Other Sector (1A4) were obtained from 2006 IPCC Guidelines. (Table 2-41)

Table 2-41: Emission factors for 1A4 Other Sectors for 2020-2022

Source/fuel	CO_2 (kg/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)	NO_x (kg/TJ)	CO (kg/TJ)	NMVOC (kg/TJ)
1A4 Other Sectors						
1A4a Commercial/Institutional						
LPG	63,100	5.00	0.10	100.00	20.00	5.00
Natural Gas	56,100	5.00	0.10	50.00	50.00	5.00
1A4b Residential						
LPG	63,100	5.00	0.10	100.00	20.00	5.00
Fuelwood	112,000	300	4	100.00	5000.00	600.00
Rice husk	100,000	300	4	100.00	5000.00	100.00
Charcoal	112,000	200	1	100.00	7000.00	600.00
Agricultural residue	100,000	300	4	100.00	5000.00	100.00
1A4c Agriculture/Forestry/Fishing						
Diesel oil	74.10	10.00	0.60	1200.00	1000.00	200.00
Biofuels	70,800	10	0.6			

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of Other Sectors, the uncertainties indicated in the 2006 IPCC Guidelines (-60% to +151% for CH_4 and -50% to +200% for N_2O) were adopted. Since the values in the annual energy reports of Ministry of Energy were used for the activity data, the default values in the 2006 IPCC Guidelines (-5% to +5%) were adopted for the uncertainty of activity data. Therefore, the uncertainty of the emissions from manufacturing industries and construction was estimated as -60% to +151% for CH_4 and -50% to +200% for N_2O.

Time-series Consistency

The same emission factors are used throughout the time series. The data given in the annual reports of the Ministry of Energy are used as activity data consistently throughout the time series.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials. The responsible agencies collected activity data and conducted their own QA/QC before sending data to the inventory compilation office at the Department of Climate Change and Environment (DCCE). In addition, at the DCCE a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures

Category-specific Planned Improvements

No planned improvements in Other Sectors (1A4) are planned.

Estimated CO_2, CH_4 and N_2O Emissions in the Other Sectors (1A4)

Table 2-42 presents estimated CO_2, CH_4 and N_2O emissions of Other Sectors (1A4) for 2020-2022. Total GHG emissions in Other Sectors (1A4) in 2022. Total GHG emissions in Other Sectors (1A4) are estimated at 14,466.63, 14,093.84 and 13,990.18 $ktCO_2eq$ for 2020, 2021 and 2022, respectively. Trends of total GHG emissions in Other Sectors (1A4) were decreasing after 2012. (Figure 2-23) CO_2 emissions decreased from 20,711.78 $ktCO_2eq$ in 2012 to 12,726.41 $ktCO_2eq$ in 2022. Trends of CH_4 and N_2O emissions in Other Sectors (1A4) in the time series were found to be decreasing from 2018 to 2022 at 1,122.75 and 141.02 $ktCO_2eq$, respectively (Figure 2-24).

Table 2-42: CO_2, CH_4 and N_2O emissions in Other Sectors (1A4) for 2020-2022

Year	CO_2 ($ktCO_2eq$)	CH_4 ($ktCO_2eq$)	N_2O ($ktCO_2eq$)	Total ($ktCO_2eq$)
2020	13,008.30	1,296.71	161.65	14,466.57
2021	12,853.41	1,101.45	138.98	14,093.84
2022	12,726.41	1,122.75	141.02	13,990.18

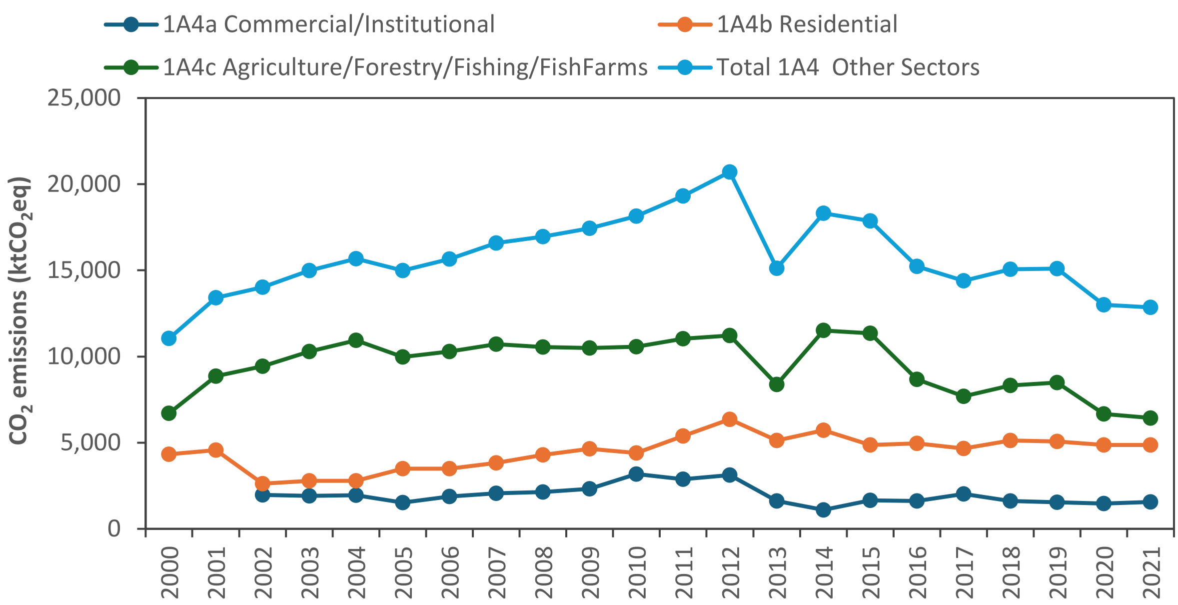


Figure 2-23: CO_2 emission from Other Sectors (1A4) for 2000-2022

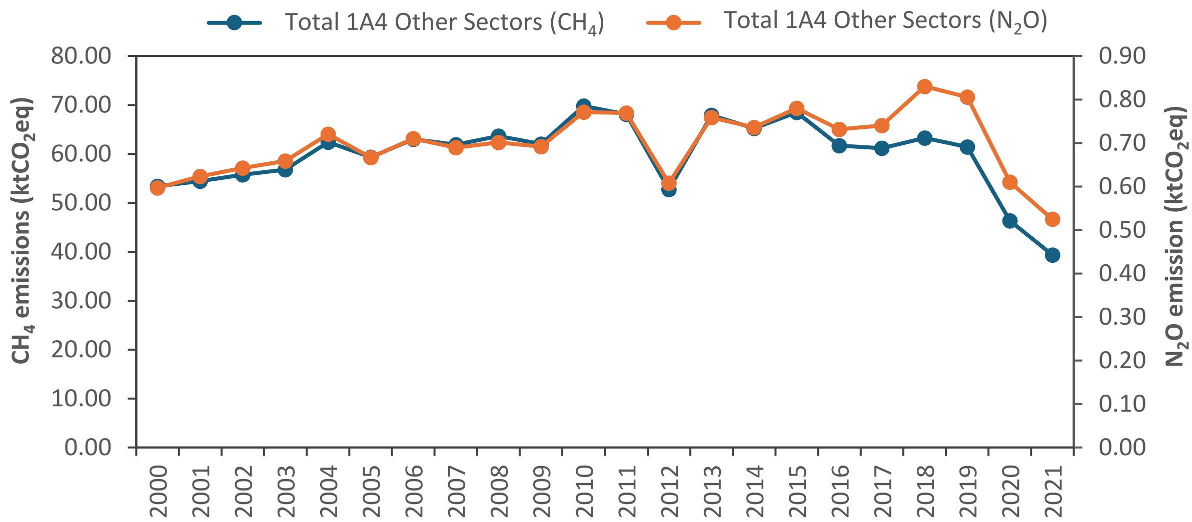


Figure 2-24: CH_4 and N_2O emissions in Other Sectors (1A4) for 2000-2022

Estimated Indirect Emissions in the Other Sectors (1A4)

In addition to GHG emissions, the indirect emissions in the Other Sectors (1A4) are also estimated for NO_x, CO, NMVOC and SO_2 using default emissions factors from IPCC Guidelines (Table 2-43). Trends of all indirect emissions in the time series were increasing during 2000-2012, and then decreasing (Figure 2-25).

Table 2-43: Indirect emissions in Other Sectors (1A4) for 2020-2022

Year	NO_X (kt)	CO (kt)	NMVOC (kt)	SO_2 (kt)
2020	134.19	895.17	114.89	28.45
2021	127.96	766.88	99.24	24.85
2022	124.71	777.92	100.32	24.98

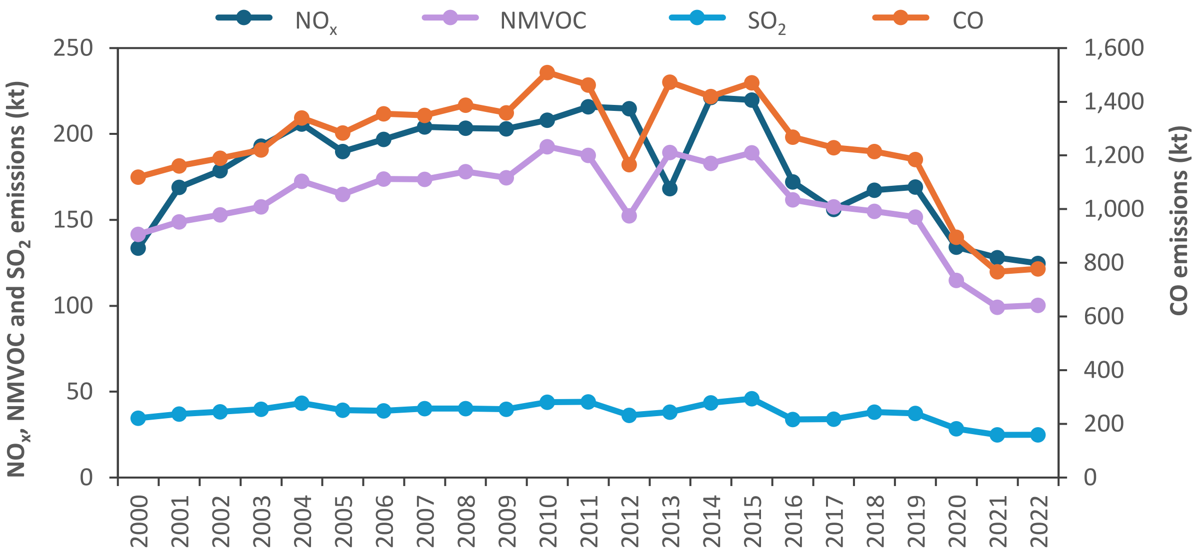


Figure 2-25: Indirect emissions from Other Sectors (1A4) for 2000-2022

Fugitive Emissions of Fuels (1B)

Category Description

This section provides the estimation methods for CO_2, CH_4 and N_2O emissions from Fugitive Emissions of Fuels (1B) in Thailand. Emissions from sources are estimated for fugitive emissions of solid fuels (1B1), and fugitive emissions from oil and gas industries (1B2). (Figure 2-26).

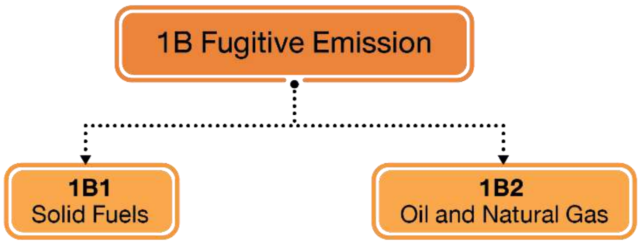


Figure 2-26: Emissions sources of Fugitive Emissions (1B) in Thailand

Estimation Method

The CO_2, CH_4 and N_2O emissions were calculated by using the Tier 1 method for aggregated activity data and default emission factors in accordance with the decision tree of the 2006 IPCC Guidelines (Vol. 2). The decision tree in Vol.2 Page 4.18, Fig. 4.1.2 was applied to estimate fugitive emissions from surface coal mining. The decision trees in Vol.2 Page 4.38, Fig. 4.2.1 and Vol.2 Page 4.39, Fig. 4.2.2 were applied to estimate fugitive emissions from natural gas system, and oil production, respectively. The decision tree in Vol.2 Page 4.40, Fig. 4.2.3 was applied to estimate fugitive emissions from crude oil transport, refining and upgrading.

Activity Data of Fugitive Emissions (1B)

Activity data for the fugitive emissions from surface coal mining were obtained from a collection of the official reports and documents of coal production in Thailand from energy reports and annual reports from the Department of Primary Industries and Mines (DPIM) Ministry of Industry. Activity data for the fugitive emissions from oil production were obtained from a collection of the official reports and documents of oil and gas production in Thailand from annual energy reports from the Department of Mineral Fuels (DMF), Ministry of Energy. The information obtained was analyzed, examined, and calculated for the greenhouse gas emissions. Activity data for fugitive emissions from petroleum refining were obtained from the Energy Balance of Thailand of the Ministry of Energy (Tables 2-44 and 2-45).

Table 2-44: Activity data for Fugitive emissions from Coal Mining (1B1a) for 2020-2022

Year	Coal production (tonne)
2020	13,250,574
2021	14,221,573
2022	13,641,283

Table 2-45: Activity data for Fugitive emissions from Oil and Gas (1B2) for 2020-2022

Number of Well drilling	Number of Well testing	Oil production ('000 m^3)	Oil transport ('000 m^3)	Gas production (million m^3)
2020				
342	2	6,823.73	7,263.78	29,732.69
2021				
271	1	5,542.30	5,845.04	28,242.66
2022				
353	0	4,589.96	4,752.69	22,759.10

Emission Factors of Fugitive Emissions from Coal Mining (1B1a)

Typically, the depth of surface coal mining in Thailand is over 50 m. The IPCC default emission factors are applied to Fugitive Emissions from Coal Mining (1B1a), as shown in Table 2-46.

Table 2-46: Emission factors for 1B1 Fugitive emissions (Solid) for 2020-2022

Coal mining	CH_4 Emission factor
Surface mining (High), over 50-m depth	CH_4 Emission Factor = 2.0 m^3/tonne
Post-Mining Activities (High), over 50-m depth	CH_4 Emission Factor = 0.2 m^3/tonne

Emission Factors of Fugitive Emissions from Oil and Natural Gas (1B2)

Fugitive Emissions from Oil and Natural Gas (1B2) in Thailand were estimated using aggregated activity data from oil and gas production. Thus, IPCC default emission factors of these fugitive emissions were used in estimation of emissions. (Table 2-47)

Table 2-47: Emission factors for 1B2 Fugitive emissions from Oil and Gas for 2020-2022

	CO_2 Emission Factor Gg/1000 m^3	CH_4 Emission Factor Gg/1000 m^3
Crude oil (million liters)	0.000000043	0.00000059
Natural gas (mmscf)	0.000097000	0.01219000
Oil refinery (million m^3)	0.000041100	-

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of Fugitive Emissions, the uncertainties indicated in the 2006 IPCC Guidelines (-60% to +151% for CH_4 and -50% to +200% for N_2O) were adopted. Since the values in the annual reports of Ministry of Energy were used for the activity data, the default values in the 2006 IPCC Guidelines (-5% to +5%) were adopted for the uncertainty of activity data. Therefore, the uncertainty of the emissions from manufacturing industries and construction was estimated as -60% to +151% for CH_4 and -50% to +200% for N_2O.

Time-series Consistency

The same emission factors are used throughout the time series. The data for estimation of fugitive emissions from solid fuels given in the Production Statistics of the Department of Primary Industries and Mines (DPIM) the Ministry of Industry, and data for estimation of fugitive emissions from oil production and natural gas system given in the annual energy reports of the Ministry of Energy are used as activity data consistently throughout the time series.

Category-specific QA/QC procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials. The activity data for estimation of fugitive emissions from solid fuels were initially checked by the Department of Primary Industries and Mines (DPIM) Ministry of Industry. The activity data for estimation of fugitive emissions from oil production and natural gas system were initially checked by the Department of Mineral Fuels (DMF) Ministry of Energy before sending data to the inventory compilation office at the Department of Climate Change and Environment (DCCE). At DCCE, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures

Category-specific Planned Improvements

Emissions estimated for fugitive emissions (1B) follow the Tier 1 approach with aggregated activity data and default emission factors. Capacity building and support are needed to adopt a higher tier method. Activity data for venting and flaring of oil and gas at the disaggregated level and country-specific emission factors of Tier 2, in accordance with the good practice elaborated in the IPCC guidelines, are planned and proposed to implement before the next submission.

Estimated Emissions from Fugitive Emissions of Fuels (1B)

Only methane emissions were found in the Fugitive GHG Emissions of Fuels from Coal Mining (1B1a). CH_4 emissions are estimated at 546.84, 586.95, and 563.00 ktCO_2eq for 2020, 2021, and 2022, respectively (Table 2-48). CO_2 and CH_4 emissions are estimated for Fugitive Emissions of Fuels from Oil and Gas (1B1b) at total GHG emissions of 10,309.68, 9,781.07, and 7,931.78 ktCO_2eq for 2020, 2021, and 2022, respectively (Table 2-49). In addition to GHG emissions, NMVOC emissions are estimated for Fugitive Emissions of Fuels from Oil and Gas (1B1b) (Table 2-50).

Table 2-48: Fugitive Emissions of Fuels from Coal Mining (1B1a) for 2020-2022

Year	CO_2 (ktCO_2eq)	CH_4 (ktCO_2eq)	N_2O (ktCO_2eq)	Total (ktCO_2eq)
2020	NO	546.88	NO	546.88
2021	NO	586.95	NO	586.95
2022	NO	563.00	NO	563.00

Table 2-49: Fugitive Emissions of Fuels from Oil and Gas (1B1b) for 2020-2022

Year	CO_2 (ktCO_2eq)	CH_4 (ktCO_2eq)	N_2O (ktCO_2eq)	Total (ktCO_2eq)
2020	3.16	10,306.52	NO	10,309.68
2021	2.91	9,778.15	NO	9,781.07
2022	2.32	7,929.46	NO	7,931.78

Table 2-50: Indirect emissions of Fugitive Emissions from Oil and Gas (1B2): 2020-2022

Year	NO_X (kt)	CO (kt)	NMVOC (kt)	SO_2 (kt)
2020	NO	NO	96.31	NO
2021	NO	NO	94.12	NO
2022	NO	NO	93.79	NO

Trend of CH_4 Emission from Fugitive Emissions of Fuels from Coal Mining (1B1a)

The trend of CH_4 Emission from Fugitive Emissions of Fuels from Coal Mining (1B1a) decreased from 861.84 ktCO_2eq in 2000 to 563.00 ktCO_2eq in 2022 (Figure 2-27).

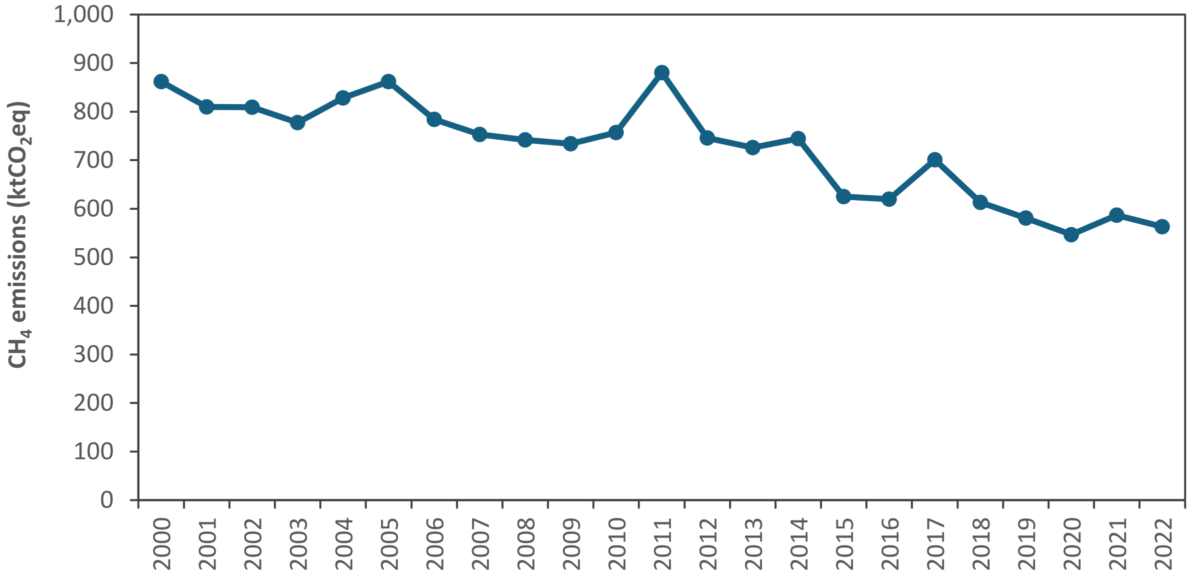


Figure 2-27: CH_4 emission from Fugitive Emissions of Fuels from Coal Mining (1B1a) for 2000-2022

Trends of CO_2 and CH_4 Emissions from Fugitive Emissions from Oil and Gas (1B2)

In the time series, the trend of CO_2 emissions from Fugitive Emissions from Oil and Gas (1B2) was found to be increasing with a sudden increase during 2011-2014. The time series CH_4 emissions from Oil and Gas (1B2) increased to its highest level at 12,500.02 ktCO$_2$eq in 2013, then decreased to 7,929.46 ktCO$_2$eq in 2022 (Figure 2-28).

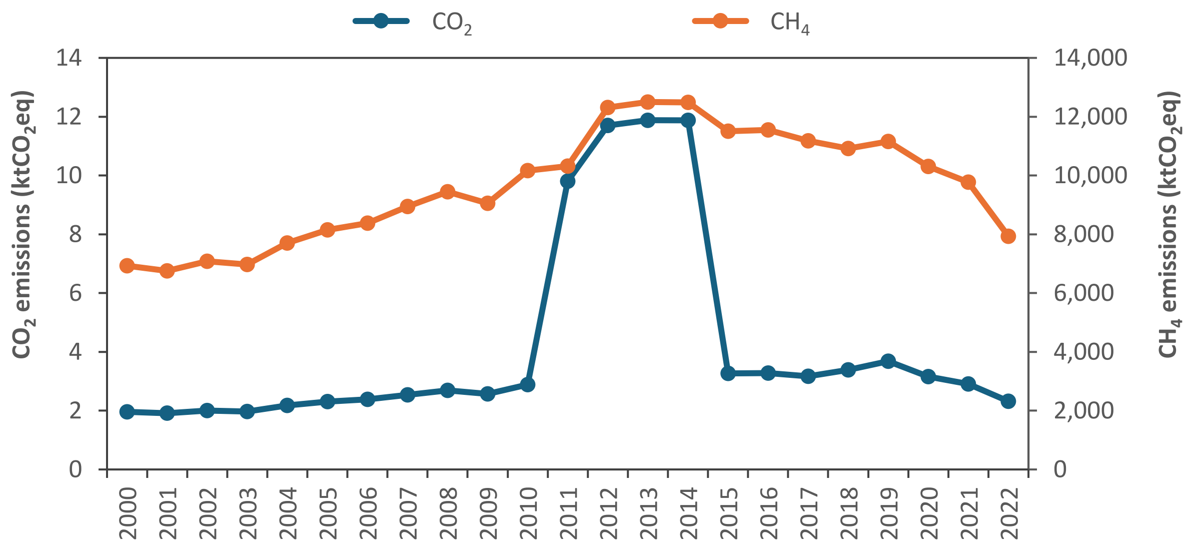


Figure 2-28: CO_2 and CH_4 emissions from Fugitive Emissions from Oil and Gas (1B2) for 2020-2022

CH_4 and N_2O Emissions from International Bunker Fuels

The emissions of CO_2, CH_4 and N_2O from this source were derived by multiplying the consumption of each fuel type handled by bonds by the emission factors. The emission factors used for CO_2 were the same as those from 1A1 fuel combustion (CO_2) in the energy sector. The default values given in the 2006 IPCC Guidelines were used for CH_4 and N_2O emission factors (Table 2-51). The time-series emissions from International Bunker Fuels are presented in Figure 2-29 for CO_2, and Figure 2-30 for CH_4 and N_2O.

Table 2-51: Emission factors for CH_4 and N_2O from international bunkers

Transport mode	Type of fuel	CH_4 emission factor [kg-CH_4/TJ (NCV)]	N_2O emission factor [kg-N_2O/TJ (NCV)]
Aircraft	Jet fuel	0.5 [1)]	2 [1)]
Shipping	Fuel oil	7 [2)]	2 [2)]

Note:
1) 2006 IPCC Guidelines Vol. 2, Table 3.6.5.
2) 2006 IPCC Guidelines Vol. 2, Table 3.5.3. According to the 2006 IPCC Guideline Vol.3 page 5.7, CH_4 and N_2O emissions from lubricants are very small in comparison to CO_2, and these can be neglected for the greenhouse gas calculation. Therefore, the emissions are not estimated.

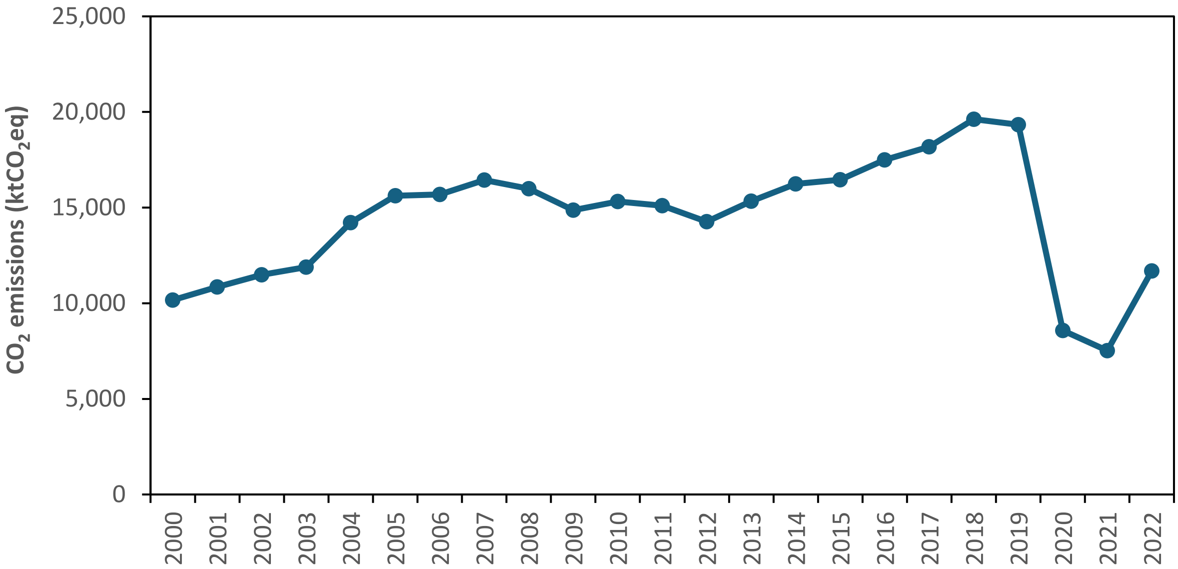


Figure 2-29: CO_2 Emissions from International Aviation (1A3ai) and Marine (1A3di) for 2000-2022

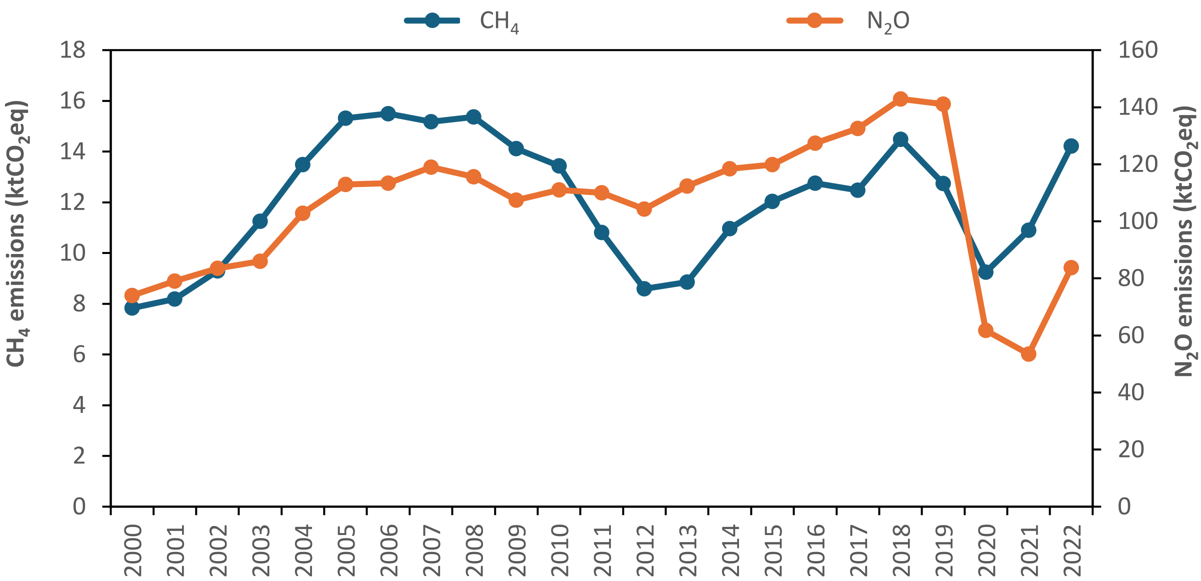


Figure 2-30: CH_4 and N_2O Emissions International Aviation (1A3ai) and Marine (1A3ai) for 2000-2022

Carbon Dioxide Transport Injection and Geological Storage (1C)

CO_2 transport and storage sector includes CO_2 emissions associated with the carbon dioxide capture and storage (CCS). CCS is the technology or methodology that captures the CO_2 which would be emitted to the atmosphere and stores it underground or under the seabed. This sector consists of three categories: i) transport of CO_2 (1C1): emissions in the stage of CO_2 transport, ii) Injection and storage (1C2): emissions in the stage of CO_2 injection and storage, and Other (1C3). CO_2 emissions in the stage of transport and injection can occur during the period of injection, and CO_2 emissions in the stage of storage can have occurred continuously since CO_2 is injected.

In the reporting period of national GHG emissions of Thailand from 2000 to 2022 in this BTR, there were no related CO_2 transport, injection and storage.

Category-specific Planned Improvements

CCS activity in Thailand was officially launched in 2023 by PTT Exploration and Production (Public Company Limited) under supervision of Ministry of Energy Thailand. Emissions from Carbon Dioxide Transport Injection and Geological Storage (1C) have been under observation. Collection of related activity data is ongoing, in accordance with the 2006 IPCC GL (Vol 2).

2.2 INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)

This section describes the methodologies of emissions estimation from the industrial process and product use emissions. The estimation methods, emission factors, activity data, QA/QC etc. of emissions sources were compiled and approved by the IPPU working group on Industrial Processes and Product Use (IPPU), and F-gases, of the Sub-committee for Greenhouse Gas Emissions Estimation (see Chapter 1 on the section "Institutional Arrangements"). The Department of Industrial Works, Ministry of Industry, as a focal point of activity data of the IPPU sector, coordinated with related agencies in the ministry and private sectors on data collection. Table 2-52 presents categories of emissions estimated in the IPPU sector in Thailand. Table 2-53 presents methodological tier used in the IPPU sector in Thailand.

Table 2-52: Emissions estimated in the IPPU sector in Thailand

IPPU	Category of Emissions Estimated in Thailand
2A Mineral Industry	2A1 Cement Production
	2A2 Lime Production
	2A3 Glass Production
	2A4 Other Process Uses of Carbonates
	2A4b Other Uses of Soda Ash 2A4d Other (Use of Calcite)
2B Chemical Industry	2B2 Nitric Acid Production
	2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production
	2B8 Petrochemical and Carbon Black Production
	2B8b Ethylene
	2B8c Ethylene Dichloride and Vinyl Chloride Monomer
	2B8e Acrylonitrile
	2B8f Carbon Black
2C Metal Production	2C1 Iron and Steel Production
2D Non-Energy Products from Fuels and Solvent Use	2D1 Lubricant Use
2F Emissions of Fluorinated Substitutes for Ozone Depleting Substances	2F1 Refrigeration and Air Conditioning
2G Other Product Manufacture and Use	2G1 Electrical Equipment
2H Other	2H1 Pulp and Paper Industry
	2H2 Food and Beverage Industry

Table 2-53: Methodological tier used in the IPPU sector in Thailand

Category	CO_2		CH_4		N_2O		HFCs		SF_6		CO		NOx		NMVOC		SO_2	
	AD	EF	AD	EF	AD	EF	AD	EF	AD	EF	AD	EF	AD	EF	AD	EF	AD	EF
2A Mineral Industry																		
2A1 Cement	T2	D																
2A2 Lime	T1	D																
2A3 Glass	T1	D																
2A4b Uses of Soda Ash	T1	D																
2A4d Other	T1	D																
2B Chemical Industry																		
2B2 Nitric Acid	T1	D			T1	D												
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production	T1	D			T1	D												
2B8b Ethylene	T1	D	T1	D														
2B8c Ethylene Dichloride and Vinyl Chloride Monomer	T1	D																
2B8e Acrylonitrile	T1	D	T1	D														
2B8f Carbon Black	T1	D	T1	D														
2C Metal Production																		
2C1 Iron and Steel	T1	D																
2D Non-Energy Products from Fuels and Solvent Use																		
2D1 Lubricant Use	T1	D																
2F Emissions of Fluorinated Substitutes for Ozone Depleting Substances																		
2F1 Refrigeration and Air Conditioning							T1	D	T1	D								
2G Other Product Manufacture and Use																		
2G1 Electrical Equipment							T1	D	T1	D								
2H Other																		
2H1 Pulp and paper											T1	D	T1	D	T1	D	T1	D
2H2 Food and Beverage															T1	D		

Note: AD: Activity Data, EF: Emission Factor, T1: Tier 1 / T2: Tier 2 / D: IPCC Default

Methodology

The methodologies and tools used for IPPU GHG inventory reporting follow the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), Good Practice Guidance, and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000). The GHG emission calculation for IPPU Sector was a Tier 1 approach as the primary basis except for Cement Production, in which Tier 2 activity data was applied with a default emission factor. Specific equations used in estimation of emissions of each sub-sector and category in the IPPU sector are described in this section.

Activity Data

The agencies within the Ministry of Industry and the private sector have provided Activity Data (AD) for the GHG inventory of the IPPU sector. According to the institutional structure for reporting greenhouse gas data, approved by the National Committee on Climate Change Policy, the Department of Industrial Works (DIW) is assigned as a leading agency to collect and report the AD in the IPPU sector. To retrieve the data, the DIW coordinates with relevant departments within the ministry and other ministries and organizations; for example, Thai Cement Manufacturers Association (TCMA), Office of Industrial Economics Ministry of Industry, Thai Customs Department Ministry of Finance, Electricity Generating Authority of Thailand, Petroleum and Energy Institute of Thailand, Iron and Steel Institute of Thailand, Department of Energy Business Ministry of Energy, Excise Department Ministry of Finance, and Office of Agricultural Economics. These agencies provide activity from annual reports. These agencies also do quality control of activity data before submission to the DIW. The DIW re-checks the accuracy of the collected data before sending it to inventory compilation teams at DCCE. The previous submission of inventory in its BUR4 presented emissions up to 2019. The activity data of each sub-sector and category in the IPPU sector in 2020, 2021 and 2022 of this inventory submission are described in the following sections.

Emission Factors

The emission factors employed in calculating greenhouse gas emissions in the IPPU sector follow the default values of the 2006 IPCC Guidelines of National Greenhouse Gas Inventories. Details of emission factors used in estimation of emissions in the IPPU sector are provided in this section.

Uncertainty of Emissions Estimation in the IPPU Sector

Combining uncertainties of activity data uncertainty and emission factor uncertainty follow 2006 IPCC Guidelines (Vol 1, Page 3.28, Eq. 3.1). The combined uncertainties as percent of emissions in 2022 also follow 2006 IPCC Guidelines (Vol 1, Page 3.28, Eq. 3.2). Results of combined uncertainties in the IPPU sector are presented in Table 2-54.

EQUATION 3.1
COMBINING UNCERTAINTIES – APPROACH 1 – MULTIPLICATION

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2}$$

Where:

U_{total} = Combining uncertainties
U_1 = Activity data's uncertainty
U_2 = Emission factor's uncertainty

EQUATION 3.2
COMBINING UNCERTAINTIES – APPROACH 1 – ADDITION AND SUBTRACTION

$$U_{total} = \frac{\sqrt{(U_1 \bullet x_1)^2 + (U_2 \bullet x_2)^2 + \ldots + (U_n \bullet x_n)^2}}{|x_1 + x_2 + \ldots + x_n|}$$

Where:

U_{Total} = the percentage uncertainty in the sum of the quantities (half the 95 percent confidence interval divided by the total (i.e., mean) and expressed as a percentage). This term 'uncertainty' is thus based upon the 95 percent confidence interval
x_i and U_i = the uncertain quantities and the percentage uncertainties associated with them, respectively.

Table 2-54: Uncertainty of Emissions Estimation in the IPPU Sector for 2020–2022

Uncertainty of Emissions Estimation in the IPPU Sector in 2020						
IPCC Category	GHGs	Emissions or removals in 2020 $ktCO_2eq$	Activity Data (AD) Uncertainty %	Emission Factor (EF) Uncertainty %	Combined Uncertainty %	Combined Uncertainty as % of Emissions in 2020, %
2A: Mineral Industry						
2A1 Cement Production	CO_2	18,554.74	2.00	8.00	8.20	0.15
2A2 Lime Production	CO_2	106.75	3.00	2.00	3.60	0.00
2A3 Glass Production	CO_2	399.93	5.00	10.00	11.20	0.00
2A4b Other Uses of Soda Ash	CO_2	274.53	3.00	5.00	5.830	0.00
2A4d Others	CO_2	422.23	3.00	5.00	5.80	0.00
2B: Chemical Industry						
2B2 Nitric Acid Production	N_2O	135.23	2.00	40.00	40.00	0.00
2B4 Caprolactam Production	N_2O	290.92	2.00	40.00	40.00	0.00
2B8b Ethylene	CO_2	10,156.48	3.00	31.62	31.80	0.66
2B8b Ethylene	CH_4	379.34	3.00	10.00	10.40	0.00
2B8c Ethylene Dichloride	CO_2	404.06	3.00	20.00	20.22	0.00
2B8e Acrylonitrile	CO_2	145.63	3.00	60.00	60.10	0.00
2B8e Acrylonitrile	CH_4	0.71	3.00	10.00	10.40	0.00
2B8f Carbon Black	CO_2	445.41	3.00	15.00	15.30	0.00
2B8f Carbon Black	CH_4	0.29	3.00	85.00	85.10	0.00
2C: Metal Industry						
2C1 Iron and Steel	CO_2	357.38	10.00	25.00	26.90	0.00
2D: Non - Energy Products from Fuels and Solvent use						
2D1 Lubricant use	CO_2	275.50	5.00	50.00	50.20	0.00
2F: Fluorinated Substitutes for Ozone Depleting Substances						
2F1 Refrigeration and AC	HFCs	6,849.58	99.00	99.00	140.00	5.86
2G: Other Product Manufacture and Use						
2G1 Electrical Equipment	SF_6	410.26	30.00	30.00	42.40	0.00
Total						6.68%
Percentage uncertainty in IPPU						25.85%

Remark: 0.00 means less than 0.005

Uncertainty of Emissions Estimation in the IPPU Sector in 2021						
IPCC Category	GHGs	Emissions or removals in 2021 $ktCO_2eq$	Activity Data (AD) Uncertainty %	Emission Factor (EF) Uncertainty %	Combined Uncertainty %	Combined Uncertainty as % of Emissions in 2021, %
2A: Mineral Industry						
2A1 Cement Production	CO_2	16,519.20	2.00	8.00	8.20	0.12%
2A2 Lime Production	CO_2	122.88	3.00	2.00	3.60	0.00%
2A3 Glass Production	CO_2	294.76	5.00	10.00	11.20	0.00%
2A4b Other Uses of Soda Ash	CO_2	284.86	3.00	5.00	5.830	0.00%
2A4d Others	CO_2	447.30	3.00	5.00	5.80	0.00%
2B: Chemical Industry						
2B2 Nitric Acid Production	N_2O	137.82	2.00	40.00	40.00	0.00%
2B4 Caprolactam Production	N_2O	310.05	2.00	40.00	40.00	0.00%
2B8b Ethylene	CO_2	11,220.26	3.00	31.62	31.80	0.80%
2B8b Ethylene	CH_4	419.08	3.00	10.00	10.40	0.00%
2B8c Ethylene Dichloride	CO_2	510.60	3.00	20.00	20.22	0.00%
2B8e Acrylonitrile	CO_2	155.20	3.00	60.00	60.10	0.00%
2B8e Acrylonitrile	CH_4	0.71	3.00	10.00	10.40	0.00%
2B8f Carbon Black	CO_2	7.86	3.00	15.00	15.30	0.00%
2B8f Carbon Black	CH_4	0.01	3.00	85.00	85.10	0.00%
2C: Metal Industry						
2C1 Iron and Steel	CO_2	437.83	10.00	25.00	26.90	0.00%
2D: Non - Energy Products from Fuels and Solvent use						
2D1 Lubricant use	CO_2	287.04	5.00	50.00	50.20	0.00%
2F: Fluorinated Substitutes for Ozone Depleting Substances						
2F1 Refrigeration and AC	HFCs	8,020.89	99.00	99.00	140.00	7.97%
2G: Other Product Manufacture and Use						
2G1 Electrical Equipment	SF_6	596.31	30%	30%	42.43%	0.00%
Total						8.90%
Percentage uncertainty in IPPU						29.83%

Remark: 0.00 means less than 0.005

Uncertainty of Emissions Estimation in the IPPU Sector in 2022						
IPCC Category	GHGs	Emissions or removals in 2022 $ktCO_2eq$	Activity Data (AD) Uncertainty %	Emission Factor (EF) Uncertainty %	Combined Uncertainty %	Combined Uncertainty as % of Emissions in 2022, %
2A: Mineral Industry						
2A1 Cement Production	CO_2	15,803.16	2.00	8.00	8.20	0.10
2A2 Lime Production	CO_2	124.67	3.00	2.00	3.60	0.00
2A3 Glass Production	CO_2	334.12	5.00	10.00	11.20	0.00
2A4b Other Uses of Soda Ash	CO_2	298.86	3.00	5.00	5.830	0.00
2A4d Others	CO_2	440.80	3.00	5.00	5.80	0.00
2B: Chemical Industry						
2B2 Nitric Acid Production	N_2O	176.49	2.00	40.00	40.00	0.00
2B4 Caprolactam Production	N_2O	245.12	2.00	40.00	40.00	0.00
2B8b Ethylene	CO_2	10,187.97	3.00	31.62	31.80	0.60
2B8b Ethylene	CH_4	380.52	3.00	10.00	10.40	0.00
2B8c Ethylene Dichloride	CO_2	528.38	3.00	20.00	20.22	0.00
2B8e Acrylonitrile	CO_2	141.25	3.00	60.00	60.10	0.04
2B8e Acrylonitrile	CH_4	0.71	3.00	10.00	10.40	0.00
2B8f Carbon Black	CO_2	7.86	3.00	15.00	15.30	0.00
2B8f Carbon Black	CH_4	0.00	3.00	85.00	85.10	0.00
2C: Metal Industry						
2C1 Iron and Steel	CO_2	425.32	10.00	25.00	26.90	0.00
2D: Non - Energy Products from Fuels and Solvent use						
2D1 Lubricant use	CO_2	292.74	5.00	50.00	50.20	0.00
2F: Fluorinated Substitutes for Ozone Depleting Substances						
2F1 Refrigeration and AC	HFCs	10,383.15	99.00	99.00	140.00	12.90
2G: Other Product Manufacture and Use						
2G1 Electrical Equipment	SF_6	756.09	30.00	30.00	42.40	0.00
Total						13.60
Percentage uncertainty in IPPU						36.90

Remark: 0.00 means less than 0.005

GHG Emissions from the IPPU sector in 2022

Total direct GHG emissions from the IPPU sector in 2022 were estimated at 40,527.22 $ktCO_2eq$. The majority of GHG emissions in the IPPU sector were generated by the Mineral Industry (2A) at 17,001.61 $ktCO_2eq$ (41.95%), mainly consisting of Cement Production at 15,803.16 $ktCO_2eq$. GHG emissions from the Chemical Industry (2B) and Product Uses as Substitutes for Ozone Depleting Substances (2F) were at 11,668.31 $ktCO_2eq$ (28.79%) and 10,383.15 $ktCO_2eq$ (25.62%), respectively. GHG emissions from the Metal Production (2C), Non-Energy Products from Fuels (2D), and Other Product Manufacture and Use (2G) accounted for only 3.64% of total GHG emissions from the IPPU sector (see Figure 2-31 and Table 2-55).

Table 2-55: Emissions from the IPPU sector in 2022

Category	CO_2	CH_4	CH_4	N_2O	N_2O	HFCs	SF_6	CO	NOx	NMVOC	SO_2	Total
	$ktCO_2eq$	kt	$ktCO_2eq$	kt	$ktCO_2eq$	$ktCO_2eq$	$ktCO_2eq$	kt	kt	kt	kt	$ktCO_2eq$
Emissions	28,585.14	13.62	381.236	1.591	421.61	10,383.15	756.09	4.93	1.32	194.18	6.16	40,527.22
2A Mineral Industry												17,001.61
2A1 Cement	15,803.16	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	
2A2 Lime	124.666	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	
2A3 Glass	334.118	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	
2A4b Soda Ash	298.862	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	
2A4d Other	440.804	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	
2B Chemical Industry												11,668.31
2B2 Nitric	NO	NO	NO	0.67	176.49	NO	NO	NO	NO	NO	NO	
2B4 Caprolactam	NO	NO	NO	0.93	245.12	NO	NO	NO	NO	NO	NO	
2B8b Ethylene	10,187.97	13.59	380.52	NO	NO	NO	NO	NO	NO	NO	NO	
2B8c Ethylene Dichloride	528.38	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	
2B8e Acrylonitrile	141.25	0.025	0.71	NO	NO	NO	NO	NO	NO	NO	NO	
2B8f Carbon Black	7.86	0.00	0.01	NO	NO	NO	NO	NO	NO	NO	NO	
2C Metal Industry												425.32
2C1 Iron and Steel	425.32	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	
2D Non-Energy Products from Fuels and Solvent Use												292.74
2D1 Lubricant Use	292.74	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	
2F Emissions of Fluorinated Substitutes for Ozone Depleting Substances												10,383.15
2F1 Refrigeration and Air Cond.	NO	NO	NO	NO	NO	10,383.15	NO	NO	NO	NO	NO	
2G Other Product Manufacture and Use												756.09
2G1 Elec Equip	NO	NO	NO	NO	NO	NO	756.09	NO	NO	NO	NO	
2H Other												
2H1 paper & pulp	NO	NO	NO	NO	NO	NO	NO	4.93	1.32	3.26	6.16	
2H2 Food Beverage	NO	NO	NO	NO	NO	NO	NO	NO	NO	190.92	NO	

Remark: 0.00 means less than 0.005.

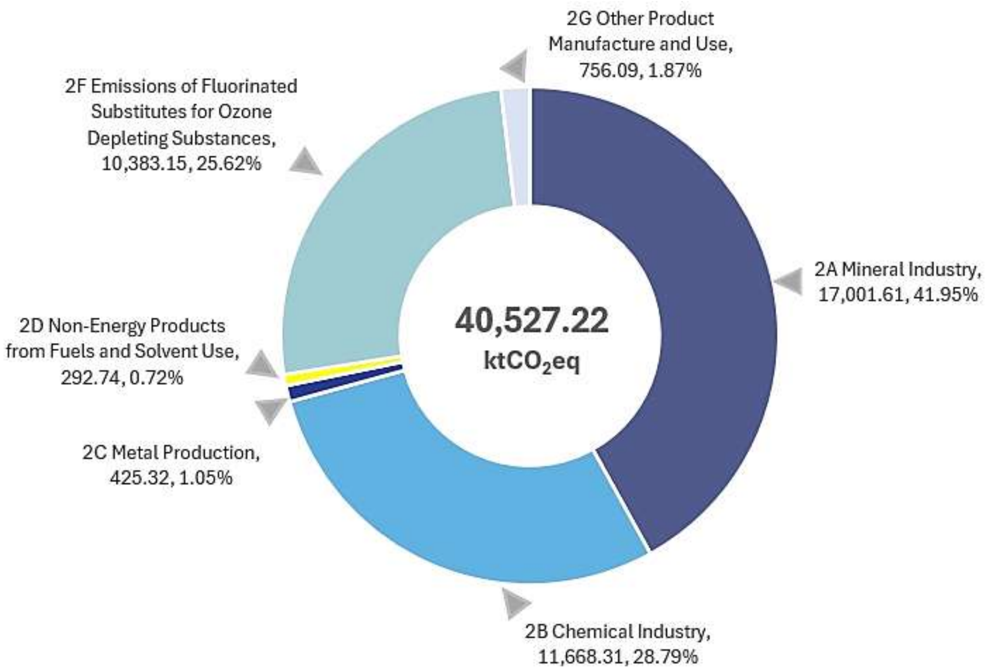


Figure 2-31: Greenhouse gas emissions from the IPPU sector in 2022

Emissions in the IPPU Sector by Type of Gas in 2022

CO_2 was the main gas of emissions in the IPPU sector, accounting for 70.53% of its emissions, mainly from Mineral Industry (2A), followed by Hydrofluorocarbons (HFCs) from Refrigeration and Air Conditioning (2F1) in the category of Emissions of Fluorinated Substitutes for Ozone Depleting Substances (2F). In 2022, the share of HFCs in the IPPU sector was 25.62% (see Figure 2-32).

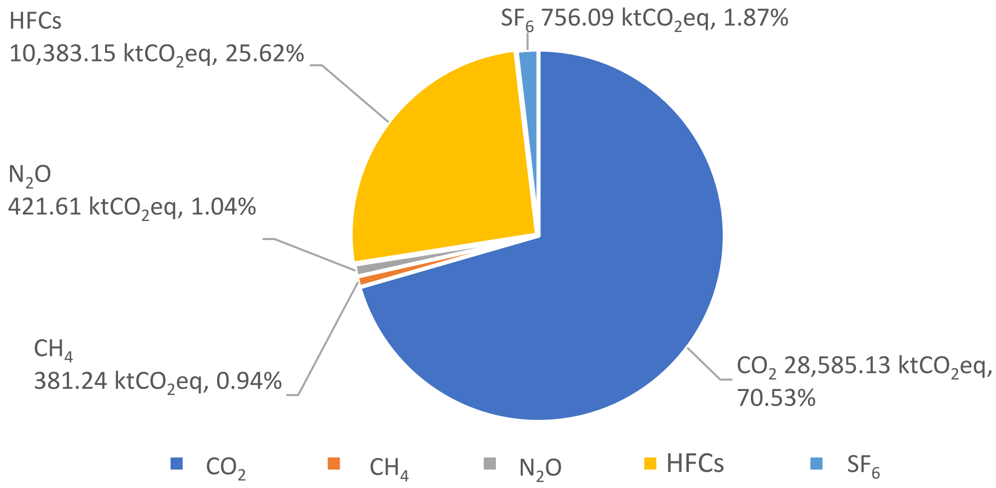


Figure 2-32: Percentage of emissions by gases (as of CO_2eq) in 2022

Trend of GHG Emissions in the IPPU sector

The trend of GHG emissions in the IPPU sector increased from 2000 to 2022. The emissions of the Mineral Industry (2A) in 2022 (17,001.61 ktCO_2eq) were slightly lower than emissions in the 2019 level (19,392.59 ktCO_2eq). Emissions of the Chemical Industry (2B) have been increasing since 2000. Emissions of the Chemical Industry (2B) peaked at 13,231.25 ktCO_2eq in 2019, and decreased to 11,668.31 ktCO_2eq in 2022. (Figure 2-33) On the other hand, the trend of Emissions of Fluorinated Substitutes for Ozone Depleting Substances (2F) has been mainly increasing in the last decade. In 2022, emissions of 2F hit 10,383.15 ktCO_2eq (25.62%).

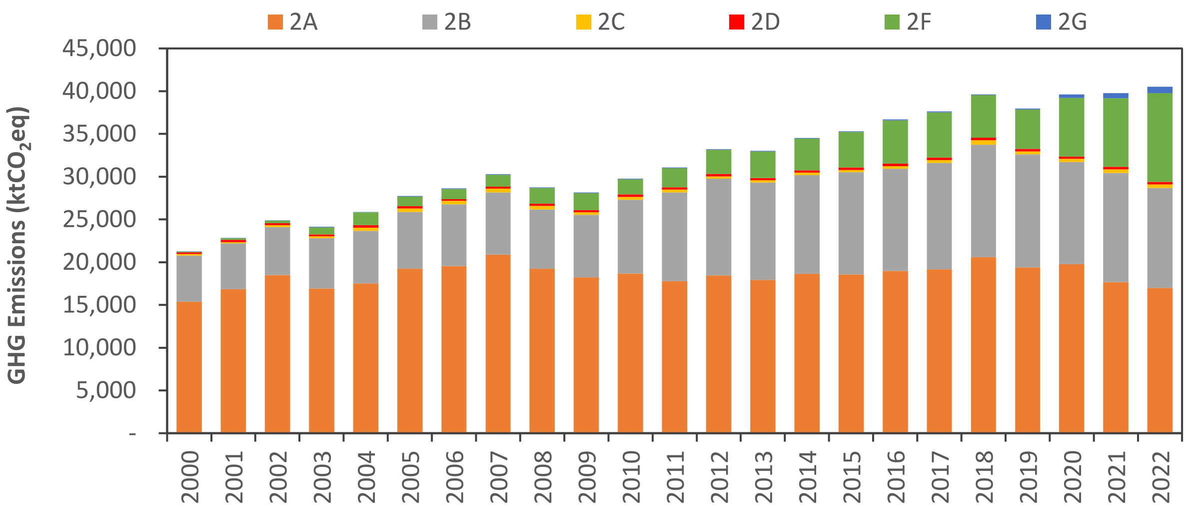


Figure 2-33: Trend of GHG emissions in the IPPU sector for 2000-2022

Mineral Industry (2A)

Category Description

This section provides the estimation methods for CO_2 emissions from Mineral Industry (2A) in Thailand, which includes Cement Production (2A1), Lime Production (2A2), Glass Production (2A3), Other Uses of Soda Ash (2A4b), and Other (2A4d). (Figure 2-34)

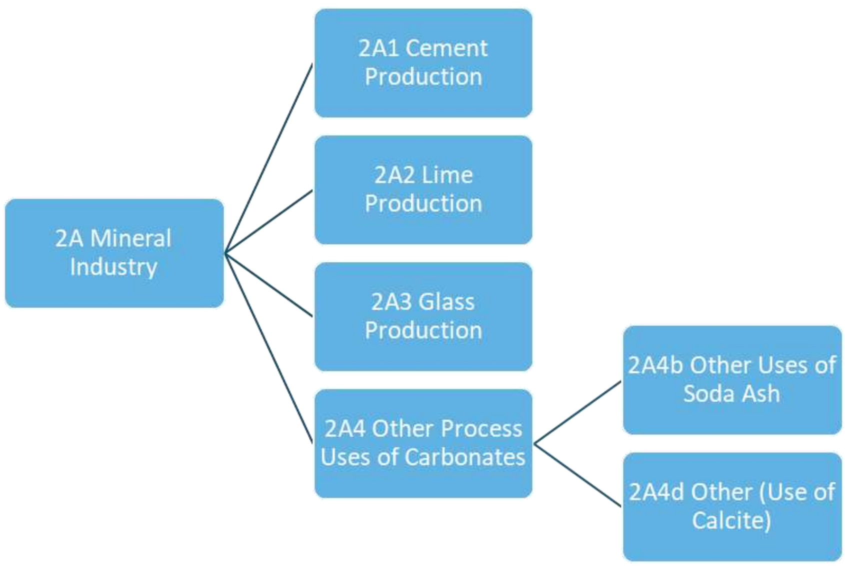


Figure 2-34: Emissions sources of Mineral Industry (2A) in Thailand for 2000-2022

Estimation Method

The CO_2 emissions from Cement Production(2A1) were calculated by using the Tier 2 method in accordance with the decision tree of the 2006 IPCC Guidelines (Vol. 3, page 2.9, Fig. 2.1). The decision tree of the 2006 IPCC Guidelines (Vol. 3, page 2.20, Fig. 2.2) was used for Lime Production (2A2). The decision tree of the 2006 IPCC Guidelines (Vol. 3, page 2.29, Fig. 2.3) was used for Glass

Production (2A3), and the decision tree of the 2006 IPCC Guidelines (Vol. 3, page 2.35, Fig. 2.4) was used for Other Process Uses of Carbonates (2A4).

Cement Production (2A1)

Greenhouse gas emissions from the cement industry are divided into 2 parts: 1) Fuel consumption and chemical reactions in the limestone or calcium carbonate ($CaCO_3$) heating process (Calcination) in the kiln at a high temperature of 1,300 degrees Celsius to obtain lime or calcium oxide (CaO), which produces carbon dioxide (CO_2). In the absence of a carbon capture process, it is assumed that CO_2 produced during this production process is released into the atmosphere, and 2) the reaction between limestone and acid induced as shown in the following chemical equations.

Calcination: $CaCO_3$ + heat ---------> CaO + CO_2

Acid-induced: $CaCO_3 + H_2SO_4$ ---------> $CaSO_4 + H_2O + CO_2$

Activity data for cement production were obtained from the Thai Cement Manufacturers Association (TCMA). Emissions based on clinker production data of TCMA were calculated following 2006 IPCC Guidelines (Vol 3, Page 2.9, Eq.2.2). An emission factor of 0.52 for clinker was employed. The correction factor of emissions for cement clinker dust (CKD) of 1.0 was recommended from cement experts and the Cement Association of Thailand.

EQUATION 2.2
TIER 2: EMISSIONS BASED ON CLINKER PRODUCTION DATA

$$CO_2\ Emissions = M_{cl} \bullet EF_{cl} \bullet CF_{ckd}$$

Where:

$CO_2\ Emissions$ = emission of CO_2 from cement production, tonnes
M_{cl} = weight (mass) of clinker produced, tonnes
EF_{cl} = emission factor for clinker, tonnes CO_2/tonne clinker
CF_{ckd} = emissions correction factor for CKD, dimensionless

Lime Production (2A2)

Tier 1 is an output-based method for emissions estimation of Lime Production (2A2). It applies an emission factor to the total quantity of lime produced. According to 2006 IPCC Guidelines (Vol 3, Page 2.22, Table 4), in the absence of country specific data, it is good practice to assume 85 percent production of high calcium lime and 15 percent production of dolomitic lime. Based on this, Equation 2.8 of 2006 IPCC Guidelines (Vol 3, Page 2.22, Eq.2.8) illustrates how to calculate the Tier 1 emission factor for lime production. However, the emission factor of 0.77 tonnes CO_2 per tonne lime produced (EF_{Lime}) is recommended by experts for Lime Production (2A2) in Thailand.

EQUATION 2.8
TIER 1 DEFAULT EMISSION FACTOR FOR LIME PRODUCTION

$$EF_{Lime} = 0.85 \bullet EF_{high\ calcium\ lime} + 0.15 \bullet EF_{dolomitic\ lime}$$
$$= 0.85 \bullet 0.75 + 0.15 \bullet 0.77^{a}$$
$$= 0.6375 + 0.1155$$
$$= 0.75 \text{tonnes } CO_2 \text{ / tonne lime produced}$$

Glass Production

The Tier 1 method of 2006 IPCC Guidelines is used (Vol 3, Page 2.28, Eq. 2.10) where data are not available on glass manufactured by process, or the carbonates used in glass manufacturing. Tier 1 applies a default emission factor and cullet ratio to national-level glass production reports.

EQUATION 2.10
TIER 1: EMISSIONS BASED ON GLASS PRODUCTION

$$CO_2\ Emissions = M_g \bullet EF \bullet (1 - CR)$$

Where:

CO_2 Emissions = emission of CO_2 from glass production, tonnes
M_g = mass of glass produced, tonnes
EF = default emission factor for manufacturing of glass, tonnes CO_2/tonne glass
CR = cullet ratio for process (either national average or default), fraction

Other Process Uses of Carbonate (2A4b)

EQUATION 2.14
TIER 1: EMISSIONS BASED ON MASS OF CARBONATES CONSUMED

$$CO_2\ Emissions = M_c \bullet (0.85 EF_{ls} + 0.15 EF_d)$$

Where:

CO_2 Emissions = emission of CO_2 from other process uses of carbonates, tonnes
M_c = mass of carbonate consumed, tonnes
EF_{ls} or EF_d = emission factor for limestone or dolomite calcination, tonnes CO_2/tonne carbonate

Other (2A4d): Use of $CaCO_3$

CO_2 emissions from the use of $CaCO_3$ to eliminate SO_2 in the lignite-fired power plants were estimated from the following chemical equation:

$$CaCO_3 + SO_2 + {}^{1}/{}_{2}\, O_2 + 2H_2O \text{ ------ > } CaSO_4 .2H_2O + CO_2$$

Activity Data of Cement production (2A1)

Activity data for cement production (2A1) were obtained from Thai Cement Manufacturers Association (TCMA) in the form of annual production. The activity data of cement production since the submission of BUR4 are presented in Table 2-56.

Table 2-56: Activity data of Cement Production (2A1) for 2020-2022

Year	Physical unit	Cement production
2020	kilo-tonne (kt)	35,682.2
2021	kilo-tonne (kt)	31,757.7
2022	kilo-tonne (kt)	30,390.7

Activity Data of Lime production (2A2)

Activity data of lime production were provided by the Department of Industrial Economics. The activity data of lime production since the submission of BUR4 are presented in Table 2-57.

Table 2-57: Activity data of Cement Production (2A1) for 2020-2022

Year	Physical unit	Lime production
2020	tonne	138,639.81
2021	tonne	159,581.41
2022	tonne	161,904.20

Activity Data of Glass production (2A3)

Activity data of glass production are provided by the Department of Industrial Economics. The activity data of glass production since the submission of BUR4 are presented in Table 2-58.

Table 2-58: Activity data of Glass Production (2A3) for 2020-2022

Year	Flat glass, tonne	Container glass, tonne
2020	822,834.23	2,228,375.17
2021	642,052.16	1,588,994.77
2022	700,474.00	1,842,088.00

Activity Data of Other Uses of Soda Ash (2A4b)

Activity data of soda ash are provided by the Customs Department. The activity data of soda ash used in Thailand since the submission of BUR4 are presented in Table 2-59.

Table 2-59: Activity data of Other Uses of Soda Ash (2A4b) for 2020-2022

Year	Physical unit	Uses of Soda Ash
2020	tonne	661,644.83
2021	tonne	686,545.44
2022	tonne	720,288.05

Activity Data of Other (2A4d): Use of $CaCO_3$

The activity data of the use of calcite in power plants are provided by the Electricity Generating Authority of Thailand and shown in Table 2-60.

Table 2-60: Activity data of Other Use of Calcite (2A4d) for 2020-2022

Year	Physical unit	Use of Calcite
2020	tonne	960,249.35
2021	tonne	1,017,260.73
2022	tonne	1,002,487.45

Emission Factors of Cement Production (2A1)

The emission factors employed in estimation of greenhouse gas emissions in cement production follow the default values of the 2006 IPCC Guidelines of National Greenhouse Gas Inventories for all fuel types. This value is agreed by experts and cement producers in Thailand. (Table 2-61)

Table 2-61: CO_2 emission factor of Cement Production (2A1) for 2000-2022

Parameter	Value
Emission factor for clinker (EF_{cl})	0.52 tonnes CO_2/tonne clinker

Emission Factors of Lime Production (2A1)

The default emission factor for developing countries of 0.77 tonnes CO_2 per tonne lime was employed from 2006 IPCC Guidelines (Vol 3, Page 2.22, Table 2.4). CO_2 emission factor of Lime Production (2A2) is shown in Table 2-62.

Table 2-62: CO_2 emission factor of Lime Production (2A2) for 2000-2022

Parameter	Value
Emission factor for (EF_{lime})	0.77 tonnes CO_2/tonne lime

Emission Factors of Glass Production (2A3)

An emission factor of 0.21 kg CO_2 per kg glass was used as shown in Table 2-63. As suggested by the IPCC Guidelines, it is good practice to use the mid-point values of cullet ratio in the ranges provided in 2006 IPCC Guidelines (Vol3, Page 2.30, Table 2.6). A cullet ratio of 37.5% was recommended by a conclusion of experts and glass manufacturers in Thailand.

TABLE 2.6
DEFAULT EMISSION FACTORS AND CULLET RATIOS FOR DIFFERENT GLASS TYPES

Glass Type	CO_2 Emission Factor (kg CO_2/kg glass)	Cullet Ratio (Typical Range)
Float	0.21	10% - 25%
Container (Flint)	0.21	30% - 60%
Container (Amber/Green)	0.21	30% - 80%

Table 2-63: CO_2 emission factor of Glass Production (2A3) for 2000-2022

Parameter	Value
Emission factor for (EF_{glass})	0.21 tonnes CO_2/tonne class

Emission Factors of Other Uses of Soda Ash (2A4b)

An emission factor for Other Uses of Soda Ash (2A4b) of 0. 0.41492 tonnes CO_2/tonne soda ash was obtained from 2006 IPCC Guidelines (Vol 3, Page 2.7, Table 2.1), and is presented in Table 2-64.

TABLE 2.1
FORMULAE, FORMULA WEIGHTS, AND CARBON DIOXIDE CONTENTS OF COMMON CARBONATE SPECIES*

Carbonate	Mineral Name(s)	Formula Weight	Emission Factor (tonnes CO_2/tonne carbonate)**
$CaCO_3$	Calcite*** or aragonite	100.0869	0.43971
$MgCO_3$	Magnesite	84.3139	0.52197
$CaMg(CO_3)_2$	Dolomite***	184.4008	0.47732
$FeCO_3$	Siderite	115.8539	0.37987
$Ca(Fe,Mg,Mn)(CO_3)_2$	Ankerite****	185.0225–215.6160	0.40822–0.47572
$MnCO_3$	Rhodochrosite	114.9470	0.38286
Na_2CO_3	Sodium carbonate or soda ash	106.0685	0.41492

Table 2-64: CO_2 emission factor of Other Uses of Soda Ash (2A4b) for 2000-2022

Parameter	Value
Emission factor for (EF)	0.41492 tonnes CO_2/tonne soda ash

Emission Factors of Other (2A4d): Use of Calcite

An emission factor for Use of Calcite of 0. 0.43971 tonnes CO_2/tonne calcite was obtained from 2006 IPCC Guidelines (Vol 3, Page 2.7, Table 2.1), and is presented in Table 2-65.

Table 2-65: CO_2 emission factor of Uses of Calcite (2A4d) for 2000-2022

Parameter	Value
Emission factor for (EF)	0.43971 tonnes CO_2/tonne calcite

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of the Mineral Industry, the uncertainties indicated in the 2006 IPCC Guidelines (-60% to +60% for CO_2) were adopted. Since the values in the annual report of the Ministry of Industry were used for the activity data, the default values in the 2006 IPCC Guidelines (-5% to +5%) were adopted for the uncertainty of activity data. Therefore, the uncertainty of the emissions from Thailand's Mineral Industry (2A) was estimated as 2% to 10%.

Time-series Consistency

The data of the Mineral Industry given in the annual reports of the Ministry of Industry are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported. This flexibility is used in light of domestic capacities, in accordance with the MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex), paragraph 57.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking the parameters for activity data and emission factors and the archiving of reference materials. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

Activity data for Cement Production (2A1) were obtained from cement association, representing Tier 2, but default values of emission factors were based on 2006 IPCC Guidelines. Thus, country-specific emission factors for cement production, in accordance with the good practice elaborated in the IPCC guidelines, are planned, and proposed to implement before the next submission of BTR. For lime production (2A2), glass production (2A3) and others, there are no plans for improvement due to their small shares in sectoral emissions and limitation of domestic capacity.

Estimated Emissions in the Mineral Industry (2A)

CO_2 Emission from Cement Production (2A1)

The estimated CO_2 emissions from Cement Production (2A1) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-66. The time series of CO_2 emissions from Cement Production (2A1) from 2000 to 2022 is shown in Figure 2-35. In the past decade, CO_2 emissions from Cement Production (2A1) decreased after 2018 from 19,361.06 ktCO_2 in 2019 to 18,554.74 ktCO_2 in 2020, 16,519.20 ktCO_2 in 2021, and 15,803.16 ktCO_2 in 2022.

Table 2-66: Estimated CO_2 emissions from Cement Production (2A1) for 2020-2022

Year	CO_2 emissions (ktCO_2)
2020	18,554.74
2021	16,519.20
2022	15,803.16

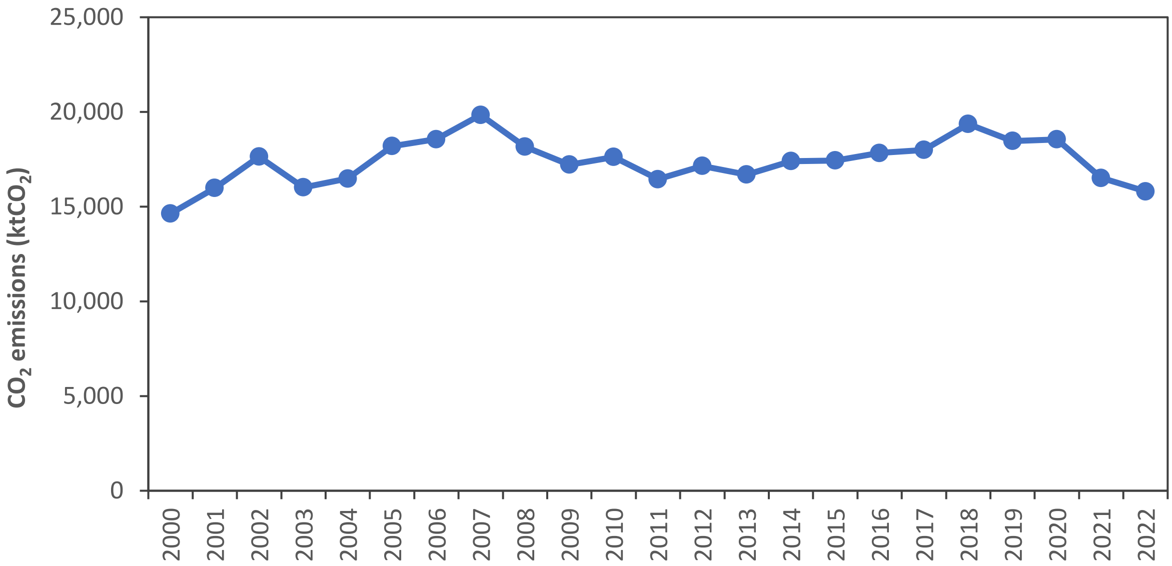


Figure 2-35: CO_2 Emission from Cement Production (2A1) for 2000-2022

CO_2 Emission from Lime Production (2A2)

The estimated CO_2 emissions from Lime Production (2A2) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-67. The time series of CO_2 emissions from Lime Production (2A2) from 2011 to 2022 is shown in Figure 2-36. CO_2 emissions from Lime Production (2A2) increased after 2018 from 117.07 ktCO_2 in 2019 to 124.67 ktCO_2 in 2022. However, the emissions trend drastically decreased from 2011 to 2015, then fluctuated in a range of 106.75 to 138.28 ktCO_2.

Table 2-67: Estimated CO_2 emissions from Lime Production (2A2) for 2020-2022

Year	CO_2 emissions ($ktCO_2$)
2020	106.75
2021	122.88
2022	124.67

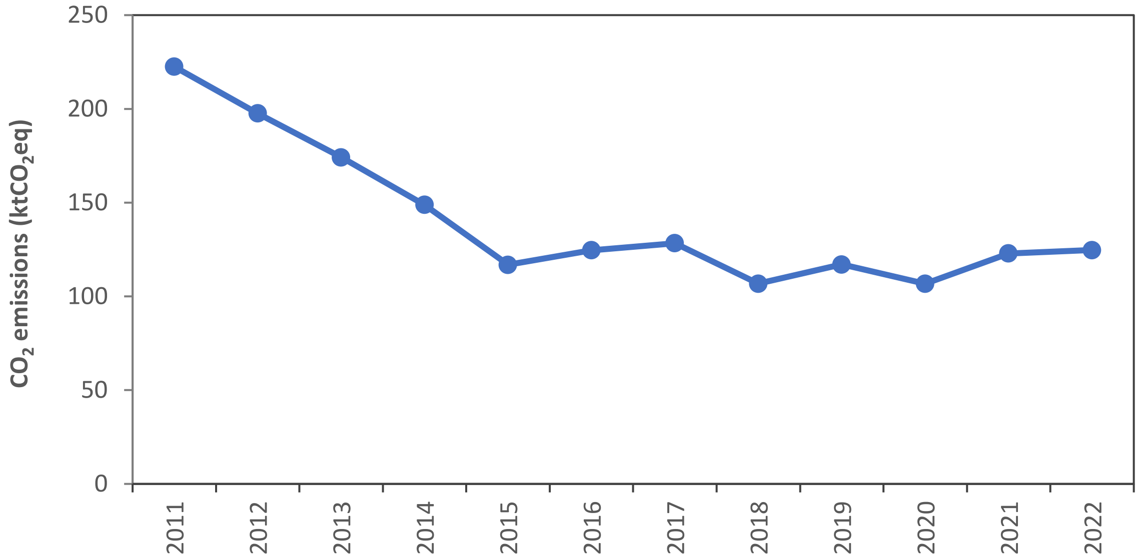


Figure 2-36: CO_2 Emission from Lime Production (2A2) for 2000-2022

CO_2 Emission from Glass Production (2A3)

The estimated CO_2 emissions from Glass Production (2A3) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-68. The time series of CO_2 emissions from Glass Production (2A3) from 2000 to 2022 is shown in Figure 2-37. The CO_2 emissions from Glass Production (2A3) have increased since 2000 from 147.24 $ktCO_2$ in 2000 to 334.12 $ktCO_2$ in 2022.

Table 2-68: Estimated CO_2 emissions from Glass Production (2A3) for 2020-2022

Year	CO_2 emissions ($ktCO_2$)
2020	399.93
2021	294.76
2022	334.12

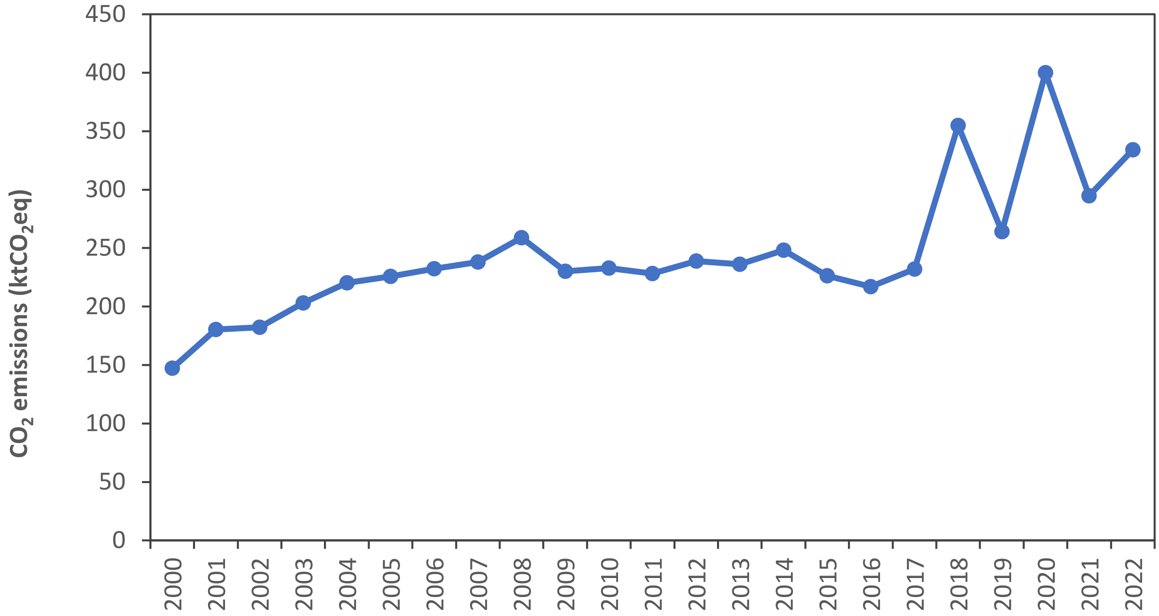


Figure 2-37: CO_2 Emission from Glass Production (2A3) for 2000-2022

CO_2 Emission from Other Uses of Soda Ash (2A4b)

The estimated CO_2 emissions from Other Uses of Soda Ash (2A4b) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-69. The time series of CO_2 emissions from Other Uses of Soda Ash (2A4b) from 2000 to 2022 is shown in Figure 2-38. CO_2 emissions from Other Uses of Soda Ash (2A4b) have increased since 2000 from 142.19 $ktCO_2$ in 2000 to 298.86 $ktCO_2$ in 2022.

Table 2-69: Estimated CO_2 emissions from Other Uses of Soda Ash (2A4b) for 2020-2022

Year	CO_2 emissions ($ktCO_2$)
2020	274.53
2021	284.86
2022	298.86

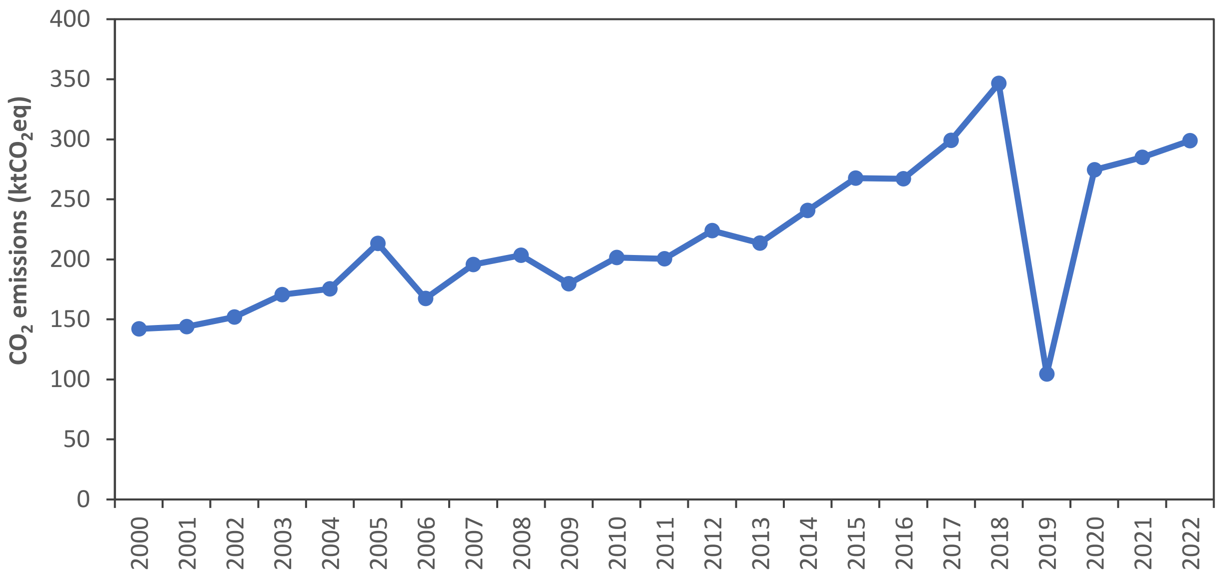


Figure 2-38: CO_2 Emission from Other Uses of Soda Ash (2A4b) for 2000-2022

CO_2 Emission from Other (2A4d)

The estimated CO_2 emissions from Use of Calcite (2A4d) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-70. The time series of CO_2 emissions from 2000 to 2022 is shown in Figure 2-39. CO_2 emissions from Use of Calcite (2A4d) have decreased since 2011 from 668.48 ktCO_2 in 2011 to 440.80 ktCO_2 in 2022.

Table 2-70: Estimated CO_2 emissions from Use of Calcite (2A4d) for 2020-2022

Year	CO_2 emissions (ktCO_2)
2020	422.23
2021	447.30
2022	440.80

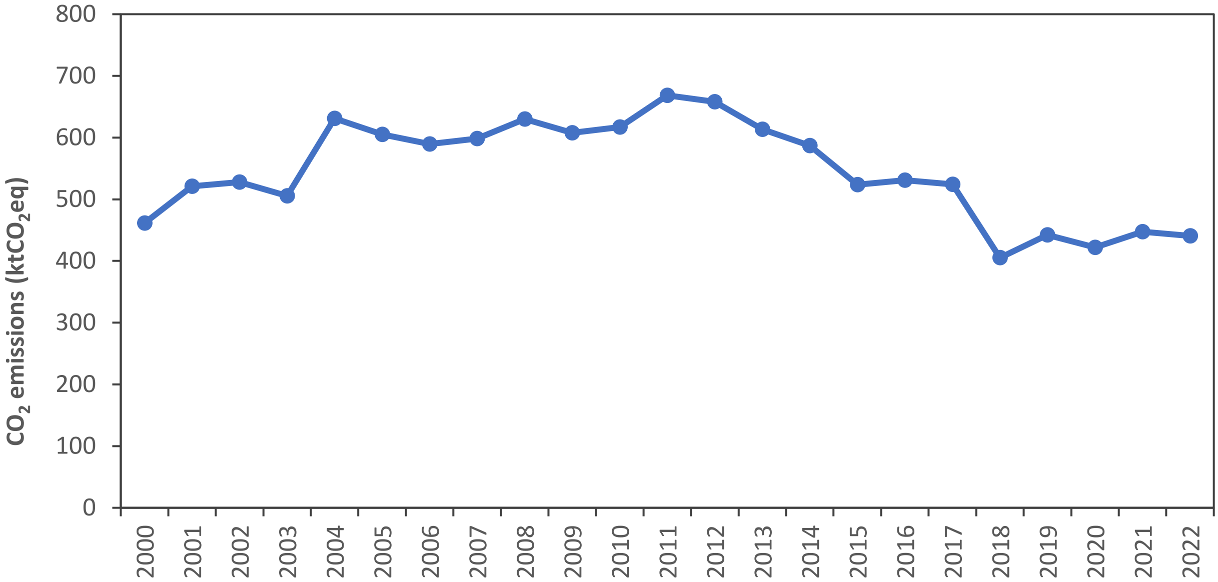


Figure 2-39: CO_2 Emission from Uses of Calcite (2A4d) for 2000-2022

Chemical Industry (2B)

Category Description

This section provides the estimation methods for CO_2, CH_4 and N_2O emissions from the Chemical Industry (2B) in Thailand, which include Nitric Acid Production (2B2), Caprolactam Production (2B4), Ethylene (2B8b), Ethylene Dichloride and Vinyl Chloride Monomer (2B8c), Acrylonitrile (2B8e), and Carbon Black (2B8f) (Figure 2-40).

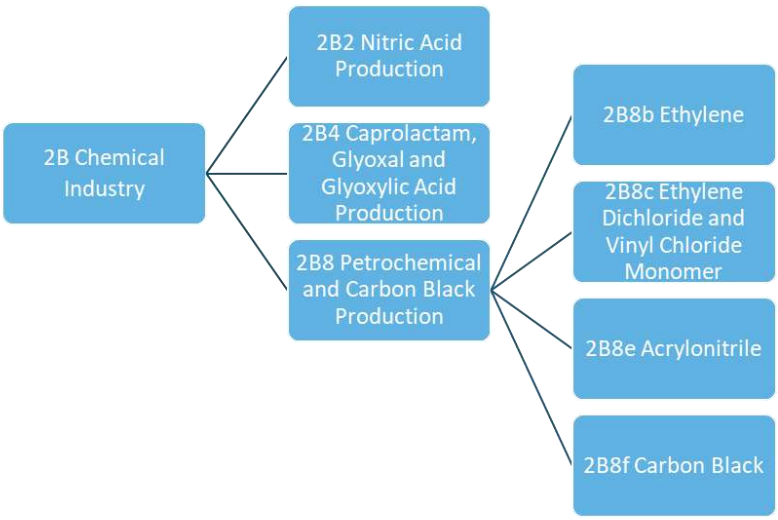


Figure 2-40: Emissions sources of Chemical Industry (2B) in Thailand for 2000-2022

Estimation Method

The CO_2 emissions from nitric acid production (2B2) were calculated by using the Tier 1 method in accordance with the decision tree of the 2006 IPCC Guidelines (Vol. 3, page 3.22, Fig. 3.2). The decision tree of the 2006 IPCC Guidelines (Vol. 3, page 3.36, Fig. 3.4) was used for caprolactam, glyoxal or glyoxylic acid production(2B4).

Method of Nitric Acid Production (2B2)

The estimated N_2O emissions from Nitric Acid Production (2B2) follow Eq.3.5 in the 2006 IPCC Guidelines (Vol 3, Page 3.21, Eq. 3.5)

EQUATION 3.5
N_2O EMISSIONS FROM NITRIC ACID PRODUCTION – TIER 1

$$E_{N2O} = EF \bullet NAP$$

Where:

E_{N2O} = N_2O emissions, kg
EF = N_2O emission factor (default), kg N_2O/tonne nitric acid produced
NAP = nitric acid production, tonnes

Method of Caprolactam Production (2B4)

The estimated N_2O emissions from Caprolactam Production (2B4) follow Eq.3.9 in the 2006 IPCC Guidelines (Vol 3, Page 3.34, Eq. 3.9). The Tier 1 was applied. It was assumed that there was no abatement of N_2O emissions and the highest default emission factor in Table 3.5 in the 2006 IPPC GL (Vol 3, Page 3.36, Table 3.5) was adopted as recommended in the good practice.

EQUATION 3.9
N_2O EMISSIONS FROM CAPROLACTAM PRODUCTION – TIER 1

$$E_{N2O} = EF \bullet CP$$

Where:

E_{N2O} = N_2O emissions, kg
EF = N_2O emission factor (default), kg N_2O/tonne caprolactam produced
CP = Caprolactam Production, tonnes

Method of Petrochemical and Carbon Black Production (2B8)

The estimated CO_2 emissions from Petrochemical and Carbon Black Production (2B8) follow 2006 IPCC Guidelines (Vol 3, Page 3.65, Eq. 3.15)

EQUATION 3.15
TIER 1 CO_2 EMISSION CALCULATION

$$ECO2_i = PP_i \bullet EF_i \bullet GAF / 100$$

Where:

E_{CO2i} = CO_2 emissions from production of petrochemical i, tonnes
PP_i = annual production of petrochemical i, tonnes
EF_i = CO_2 emission factor for petrochemical i, tonnes CO_2/tonne product produced
GAF = Geographic Adjustment Factor

Activity Data of Nitric Acid Production (2B2)

Activity data since the submission of Thailand's BUR4 for Nitric Acid Production (2B2) for 2020, 2021 and 2022 were obtained from the Department of Industrial Works (DIW), Ministry of Industry, and are presented in Table 2-71.

Table 2-71: Activity data of Nitric Acid Production (2B2) for 2020-2022

Year	Physical unit	Nitric acid production
2020	tonne	56,700
2021	tonne	57,785
2022	tonne	74,000

Activity Data of Caprolactam Production (2B4)

Activity data for Caprolactam Production (2B4) for 2020, 2021 and 2022 were obtained from the Department of Industrial Works (DIW), Ministry of Industry, and are presented in Table 2-72.

Table 2-72: Activity data of Caprolactam Production (2B4) for 2020-2022

Year	Physical unit	Nitric acid production
2020	tonne	121,268
2021	tonne	130,000
2022	tonne	102,776

Activity Data of Petrochemical and Carbon Black Production (2B8)

Activity data for Petrochemical and Carbon Black Production (2B8) for 2020, 2021 and 2022 were obtained from the Department of Industrial Works (DIW), Ministry of Industry, and the Petroleum and Energy Institute of Thailand, and are presented in Table 2-73.

Table 2-73: Activity data of Petrochemical and Carbon Black Production (2B8) for 2020-2022

Year	Production, tonne					
	Ethylene (2B8b)	Ethylene Dichloride, Chlorine (2B8c)	Ethylene Dichloride, O_2 (2B8c)	Vinyl Chloride Monomer (2B8c)	Acrylonitrile (2B8e)	Carbon Black (2B8f)
2020	4,516,000	358,234.33	180,152.06	1,007,173.16	145,634.51	170,004.80
2021	4,989,000	429,579.00	651,952.35	993,077.84	155,195.85	3,000.00
2022	4,530,000	461,152.00	671,923.25	1,019,191.59	141,251.74	3,200.00

Emission Factors of Nitric Acid Production (2B2)

The production process of nitric acid in Thailand uses high-pressure plants. The emission factors employed in calculating greenhouse gas emissions in Nitric Acid Production (2B2) follow the default values of the 2006 IPCC Guidelines (Vol 3, Page 3.23, Table 3.3), and are presented in Table 2-74.

TABLE 3.3
DEFAULT FACTORS FOR NITRIC ACID PRODUCTION

Production Process	N_2O Emission Factor (relating to 100 percent pure acid)
Plants with NSCR[a] (all processes)	2 kg N_2O/tonne nitric acid ±10%
Plants with process-integrated or tailgas N_2O destruction	2.5 kg N_2O/tonne nitric acid ±10%
Atmospheric pressure plants (low pressure)	5 kg N_2O/tonne nitric acid ±10%
Medium pressure combustion plants	7 kg N_2O/tonne nitric acid ±20%
High pressure plants	9 kg N_2O/tonne nitric acid ±40%

Table 2-74: N_2O emission factor of Nitric Acid Production (2B2) for 2000-2022

Parameter	Value
Emission factor (EF)	9 kg N_2O/tonne nitric acid

Emission Factors of Caprolactam Production (2B4)

The emission factors employed in calculating greenhouse gas emissions in Caprolactam Production (2B4) follow the default values of the 2006 IPCC Guidelines (Vol 3, Page 3.36, Table 3.5), and are presented in Table 2-75.

TABLE 3.5
DEFAULT FACTOR FOR CAPROLACTAM PRODUCTION

Production Process	N_2O Emission Factor (kg N_2O/tonne caprolactam)	Uncertainty
Raschig	9.0[a]	± 40%

Table 2-75: N_2O emission factor of Caprolactam Production (2B4) for 2000-2021

Parameter	Value
Emission factor (EF)	9 kg N_2O/tonne Caprolactam

Emission Factors of Petrochemical and Carbon Black Production (2B8)

The CO_2 emission factors employed in calculating greenhouse gas emissions for Ethylene (2B8b) follow the default values of the 2006 IPCC Guidelines (Vol 3, Page 3.36, Table 3.14), and CH_4 emission factors follow the default values of the 2006 IPCC Guidelines (Vol 3, Page 3.36, Table 3.16), using a geographic adjustment factor of 130% from 2006 IPCC Guidelines (Vol 3, Page 3.36, Table 3.15).

TABLE 3.14
STEAM CRACKING ETHYLENE PRODUCTION TIER 1 CO_2 EMISSION FACTORS

	tonnes CO_2/tonne ethylene produced					
Feedstock	Naphtha	Gas Oil	Ethane	Propane	Butane	Other
Ethylene (Total Process and Energy Feedstock Use)	1.73	2.29	0.95	1.04	1.07	1.73
- Process Feedstock Use	1.73	2.17	0.76	1.04	1.07	1.73
- Supplemental Fuel (Energy Feedstock) Use	0	0.12	0.19	0	0	0

TABLE 3.15
DEFAULT GEOGRAPHIC ADJUSTMENT FACTORS FOR TIER 1 CO_2 EMISSION FACTORS FOR STEAM CRACKING ETHYLENE PRODUCTION

Geographic Region	Adjustment Factor	Notes
Western Europe	100%	Values in Table 3.14 are based on data from Western European steam crackers
Eastern Europe	110%	Not including Russia
Japan and Korea	90%	
Asia, Africa, Russia	130%	Including Asia other than Japan and Korea
North America and South America and Australia	110%	

TABLE 3.16
DEFAULT METHANE EMISSION FACTORS FOR ETHYLENE PRODUCTION

Feedstock	kg CH_4/ tonne ethylene produced
Ethane	6
Naphtha	3
All Other Feedstocks	3

Source: EEA, 2005 (EMEP/CORINAIR Emission Inventory Guidebook)
Uncertainty values for this table are included in Table 3.27.

For Ethylene Dichloride (2B8c), the emissions factors follow the default values of the 2006 IPCC Guidelines (Vol 3, Page 3.77, Table 3.17). For Vinyl Chloride Monomer (2B8c), the emissions factors follow the default values of the 2006 IPCC Guidelines (Vol 3, Page 3.77, Table 3.17). For Acrylonitrile (2B8e), the emissions factors follow the default values of the 2006 IPCC Guidelines (Vol 3, Page 3.79, Table 3.22). For Carbon Black (2B8f), the emissions factors follow the default values of the 2006 IPCC Guidelines (Vol 3, Page 3.80, Table 3.23). The emission factors of Petrochemical and Carbon Black Production (2B8) used in estimation of emissions are summarized in Table 2-76.

TABLE 3.17 ETHYLENE DICHLORIDE/VINYL CHLORIDE PRODUCTION PROCESS TIER 1 CO_2 EMISSION FACTORS		
Process Configuration	**tonne CO_2/tonne EDC produced**	**tonne CO_2/tonne VCM produced**
Direct Chlorination Process		
Noncombustion Process Vent	negligible emissions	negligible emissions
Combustion Emissions	0.191	0.286
Total CO_2 Emission Factor	**0.191**	**0286**
Oxychlorination Process		
Noncombustion Process Vent	0.0113	0.0166
Combustion Emissions	0.191	0.286
Total CO_2 Emission Factor	**0.202**	**0.302**
Balanced Process [default process]		
Noncombustion Process Vent	0.0057	0.0083
Combustion Emissions	0.191	0.286
Total CO_2 Emission Factor	**0.196**	**0.294**

TABLE 3.22 ACRYLONITRILE PRODUCTION CO_2 EMISSION FACTORS	
Process Configuration **Direct Ammoxidation of Propylene**	**tonnes CO_2/tonne acrylonitrile produced**
Secondary Products Burned for Energy Recovery/Flared (default)	1.00
Acetonitrile Burned for Energy Recovery/Flared	0.83
Acetonitrile and Hydrogen Cyanide Recovered as Product	0.79

TABLE 3.23 CARBON BLACK PRODUCTION TIER 1 CO_2 EMISSION FACTORS			
Process Configuration	**tonnes CO_2/tonne carbon black produced**		
	Primary Feedstock	**Secondary Feedstock**	**Total Feedstock**
Furnace Black Process (default process)	1.96	0.66	2.62
Thermal Black Process	4.59	0.66	5.25
Acetylene Black Process	0.12	0.66	0.78

TABLE 3.24 CARBON BLACK PRODUCTION TIER 1 CH_4 EMISSION FACTORS	
Process Configuration	**kilogram CH_4/tonne carbon black produced** (Carbon Black Process Tail Gas)
No Thermal Treatment	28.7
Thermal Treatment (default process)	0.06

Table 2-76: Emission factors of Petrochemical and Carbon Black Production (2B8) for 2000-2022

Petrochemical & Carbon Black Production (2B8)	CO_2 emission factor	CH_4 emission factor
Ethylene (2B8b)	1.73 tCO_2/tonne Ethylene	3 kg CH_4/tonne Ethylene
Ethylene Dichloride (2B8c)	0.191 tCO_2/tonne EDC (Chlorine) 0.202 tCO_2/tonne EDC (O_2)	- -
Vinyl Chloride Monomer (2B8c)	0.302 tCO_2/tonne VCM	-
Acrylonitrile (2B8e)	1.0 tCO_2/tonne Acrylonitrile	0.18 kg CH_2/tonne acrylonitrile
Carbon Black (2B8f)	2.62 tCO_2/tonne Carbon Black	0.06 kg CH_2/tonne Carbon Black

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of Petrochemical and Carbon Black Production (2B8), the uncertainties indicated in the 2006 IPCC Guidelines (-60% to +60% for CO_2, -85% to +85% for CH_4 and -40% to +40% for N_2O) were adopted. Since the values in the annual reports of Ministry of Industry were used for the activity data, the default values in the 2006 IPCC Guidelines (-3% to +3%) were adopted for the uncertainty of activity data. Therefore, the uncertainty of the emissions from Thailand's Petrochemical and Carbon Black Production (2B8) was estimated as 2% to 85%.

Time-series Consistency

The data of the Chemical Industry given in the annual reports of the Ministry of Industry are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported. This flexibility is used in light of domestic capacities, in accordance with the MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex), paragraph 57.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking the parameters for activity data and emission factors and the archiving of reference materials by the Ministry of Industry and the inventory compilation team at DCCE. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

Activity data for Caprolactam Production (2B4) before 2004 and Acrylonitrile (2B8e) before 2013 need to be sought and consulted on with experts and related agencies. Emissions estimated for the Chemical Industry (2B) follow the Tier 1 approach. In addition to disaggregate activity data, country-specific emission factors for the Chemical Industry (2B), in accordance with the good practice elaborated in the IPCC Guidelines, are planned and proposed to implement before the next submission. However, capacity building and support are needed for Thailand to adopt a higher tier method.

Emissions from Chemical Industry (2B)

N_2O Emission from Nitric Acid Production (2B2)

The estimated N_2O emissions from Nitric Acid Production (2B2) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-77. Emissions are estimated in the form of CO_2eq at 135.23, 137.82 and 176.49 ktCO_2eq in 2020, 2021 and 2022, respectively.

The time series of CO_2 emissions from 2000 to 2022 is shown in Figure 2-41. The trend of N_2O emissions from Nitric Acid Production (2B2) has fluctuated since 2011 in a wide range. However, N_2O emissions in 2022 (176.49 ktCO_2eq) were higher than the 2000 level (154.33 ktCO_2eq).

Table 2-77: Estimated N_2O emissions from Nitric Acid Production (2B1) for 2020-2022

Year	N_2O emissions (kt)	Emissions (ktCO_2eq)
2020	0.51	135.23
2021	0.52	137.82
2022	0.67	176.49

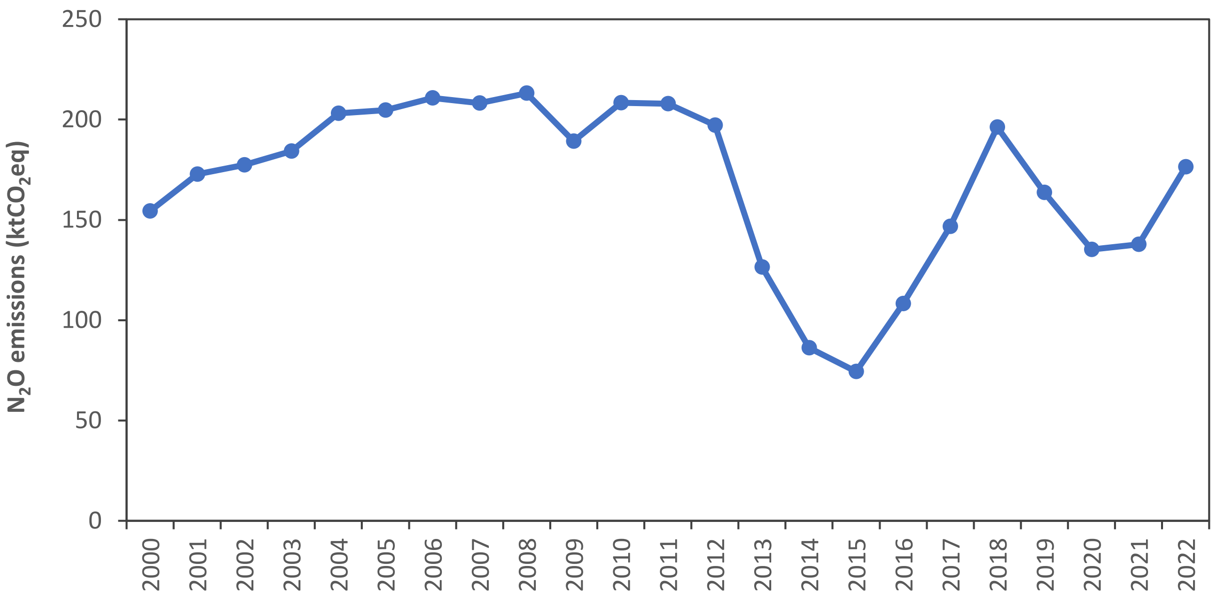


Figure 2-41: Total emissions from Nitric Acid production (2B2) for 2000-2022

N_2O Emission from Caprolactam Production (2B4)

The estimated N_2O emissions from Caprolactam Production (2B4) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-78. The time series of CO_2 emissions from 2004 to 2022 is shown in Figure 2-42. The trend of N_2O emissions from Caprolactam Production (2B4) has fluctuated since 2011 in a narrow range. However, N_2O emissions are estimated in the form of CO_2eq at 290.92, 310.05 and 245.12 ktCO_2eq in 2020, 2021 and 2022, respectively.

Table 2-78: Estimated N_2O emissions from Caprolactam Production (2B4) for 2020-2022

Year	N_2O emissions (kt)	Emissions ($ktCO_2eq$)
2020	1.09	290.92
2021	1.17	310.05
2022	0.92	245.12

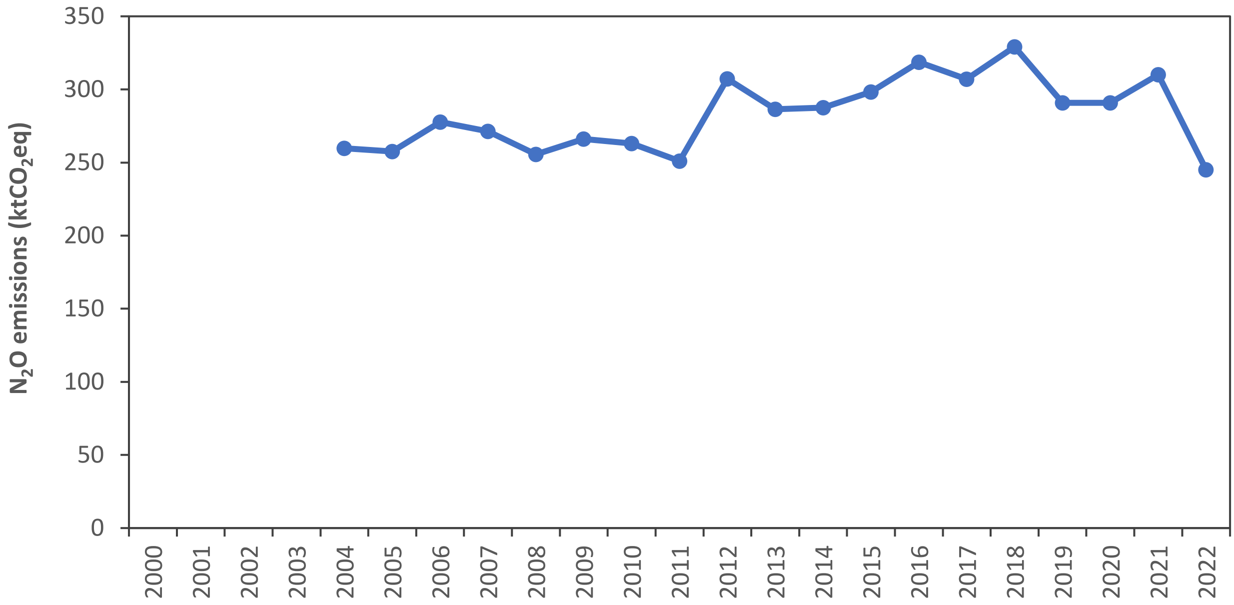


Figure 2-42: Total emissions from Caprolactam Production (2B4) for 2000-2022

CO_2 and CH_4 Emissions from Ethylene (2B8b)

The estimated CO_2 and CH_4 emissions from Ethylene (2B8b) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-79. The time series of total emissions from 2000 to 2022 is shown in Figure 2-43. Emissions from Ethylene (2B8b) are mainly carbon dioxide with methane less than a half percent. The trend of total emissions from Ethylene (2B8b) has increased since 2000. Total emissions are estimated in the form of CO_2eq at 10,535.83, 11,639.34 and 10,568.49 $ktCO_2eq$ in 2020, 2021 and 2022, respectively.

Table 2-79: Estimated CO_2 and CH_4 Emissions from Ethylene (2B8b) for 2020-2022

Year	CO_2 (kt)	CH_4 (kt)	Total CO_2 emissions ($ktCO_2eq$)
2020	10,156.48	13.54	10,535.83
2021	11,220.26	14.96	11,639.34
2022	10,187.97	13.59	10,568.49

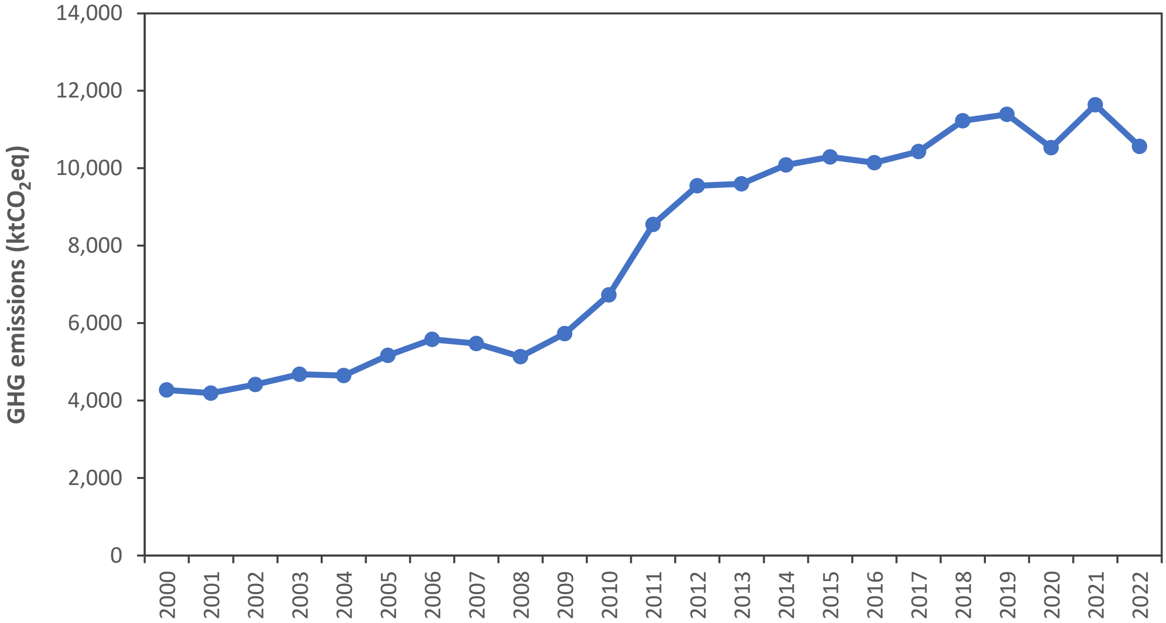


Figure 2-43: Total emissions from Ethylene (2B8b) for 2000-2022

CO_2 Emissions from Ethylene Dichloride and Vinyl Chloride Monomer (2B8c)

The estimated CO_2 emissions from Ethylene Dichloride and Vinyl Chloride Monomer (2B8c) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-80. The time series of total emissions from 2000 to 2022 is shown in Figure 2-44. The trend of total emissions from Ethylene Dichloride and Vinyl Chloride Monomer (2B8c) has increased since 2000. Total CO_2 emissions are estimated at 404.06, 510.60 and 528.38 $ktCO_2$ in 2020, 2021 and 2022, respectively.

Table 2-80: Estimated emissions from Ethylene Dichloride and Vinyl Chloride Monomer (2B8c) for 2020-2022

Year	Total ($ktCO_2$)
2020	404.06
2021	510.60
2022	528.38

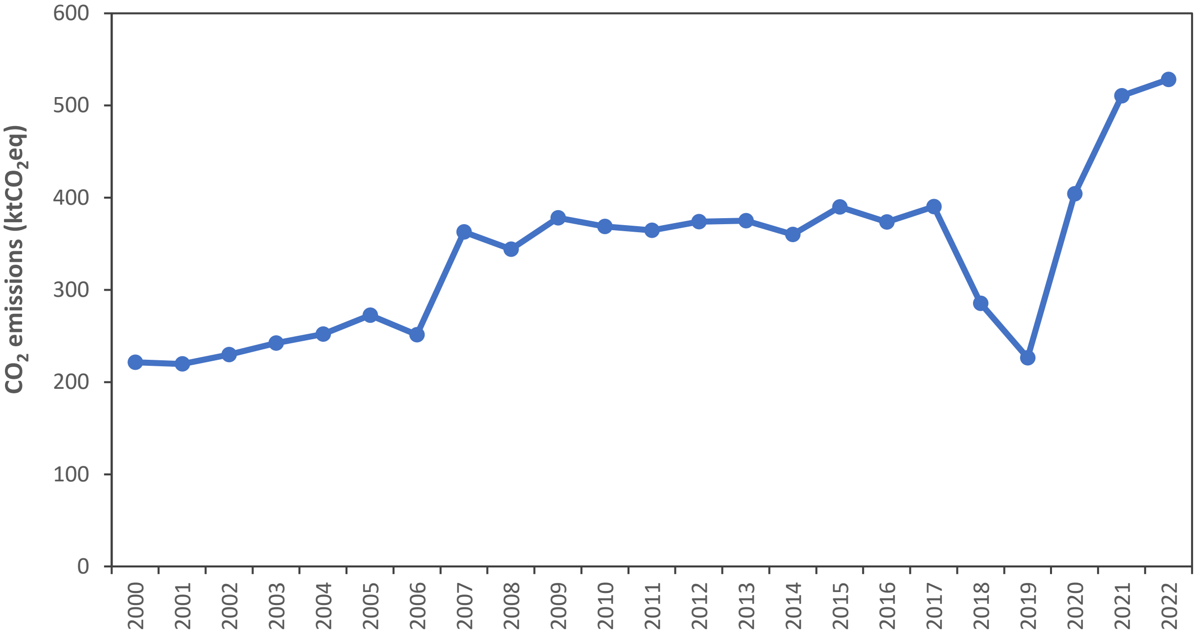


Figure 2-44: Total emissions from Ethylene Dichloride and Vinyl Chloride Monomer (2B8c) for 2000-2022

CO_2 and CH_4 Emissions from Acrylonitrile (2B8e)

The estimated CO_2 and CH_4 emissions from Acrylonitrile (2B8e) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-81. Total emissions are estimated in the form of CO_2eq at 146.37, 155.98 and 141.96 $ktCO_2eq$ in 2020, 2021 and 2022, respectively. Due to lack of activity data before 2013, only the time series of total emissions from 2013 to 2022 is shown in Figure 2-45. Emissions from Acrylonitrile (2B8e) are mainly carbon dioxide with methane less than a half percent. The trend of total emissions from Acrylonitrile (2B8e) has decreased since 2019.

Table 2-81: Estimated CO_2 and CH_4 Emissions from Acrylonitrile (2B8e) for 2020-2022

Year	CO_2 (kt)	CH_4 (kt)	CO_2 emissions ($ktCO_2eq$)
2020	145.63	0.03	146.37
2021	155.19	0.03	155.98
2022	141.25	0.03	141.96

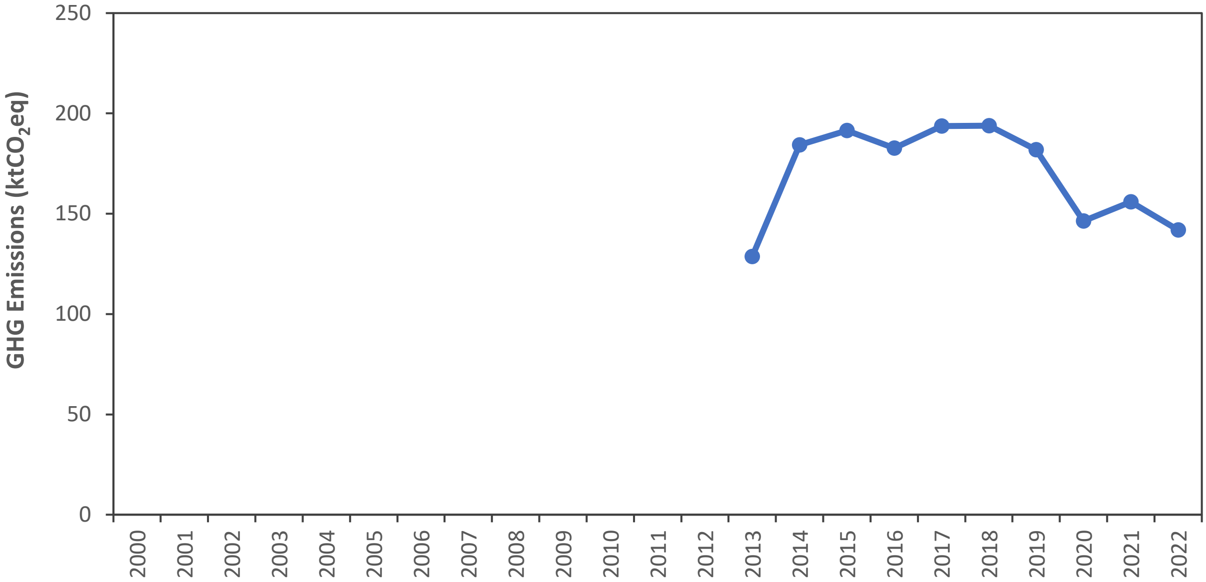


Figure 2-45: Total emissions from Acrylonitrile (2B8e) for 2000-2022

CO_2 and CH_4 Emissions from Carbon Black (2B8f)

Emissions from Carbon Black (2B8f) are mainly carbon dioxide with methane in less than a half percent. The estimated CO_2 and CH_4 emissions from Carbon Black (2B8f) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-82. Total emissions are estimated in the form of CO_2eq at 445.70, 7.87 and 7.87 ktCO_2eq in 2020, 2021 and 2022, respectively. The time series of total emissions from 2000 to 2022 is shown in Figure 2-46. The trend of total emissions from Carbon Black (2B8f) has decreased since 2019.

Table 2-82: Estimated CO_2 and CH_4 Emissions from Carbon Black (2B8f) for 2020-2022

Year	CO_2 (kt)	CH_4 (kt)	CO_2 emissions (ktCO_2eq)
2020	445.41	0.01	445.70
2021	7.86	0.00	7.87
2022	7.86	0.00	7.87

Remark: 0.00 means less than 0.005.

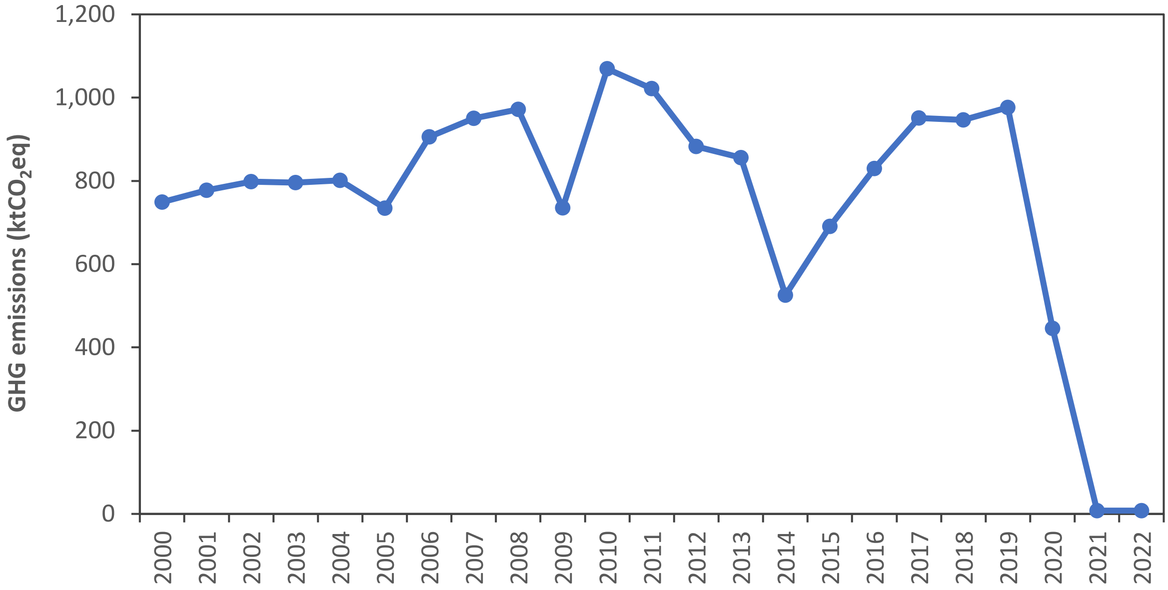


Figure 2-46: Total emissions from Carbon Black (2B8f) for 2000-2022

GHG Emissions from Chemical Industry (2B)

The time series of total emissions from the Chemical Industry (2B) from 2000 to 2022 is shown in Figure 2-47. The trend of emissions had increased since 2000. The highest value of emissions from the Chemical Industry (2B) was 13,231.25 $ktCO_2eq$ in 2019. Total emissions from the Chemical Industry (2B) decreased from 13,231.25 $ktCO_2eq$ in 2019 to 11,668.31 $ktCO_2eq$ in 2022.

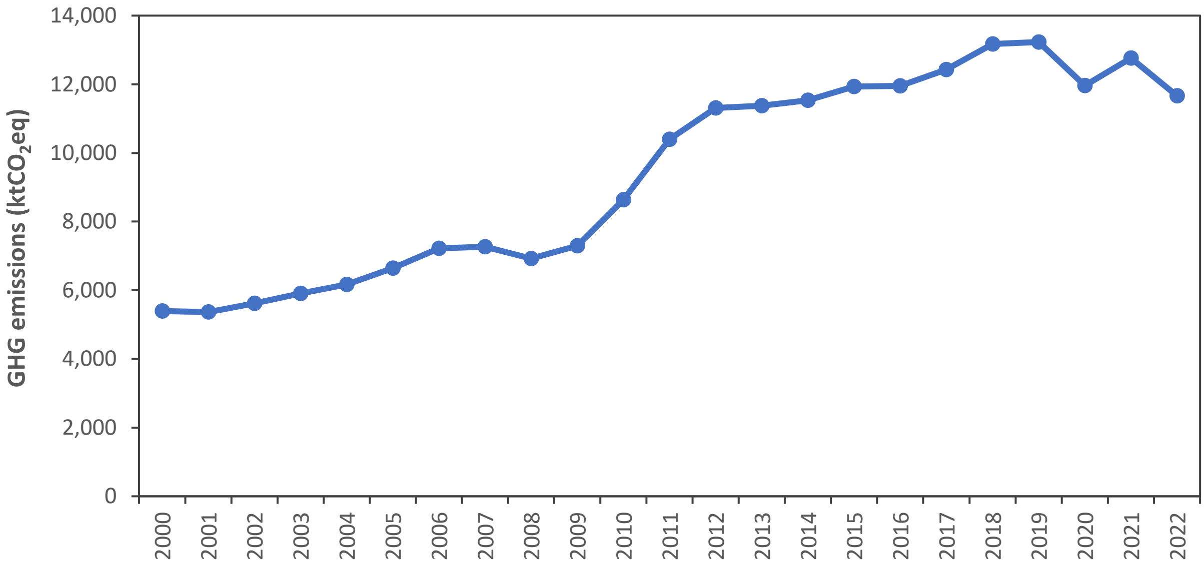


Figure 2-47: GHG Emissions from Chemical Industry (2B) for 2000-2022

Metal Production (2C)

Category Description

This section provides the estimation methods for CO_2 emissions from Metal Production (2C) in Thailand, which includes only Iron and Steel Production (2C1) (Figure 2-48).

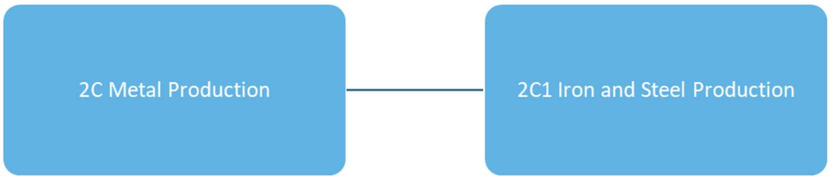


Figure 2-48: Emissions sources of Metal Production (2C) in Thailand for 2000-2021

Estimation Method for Iron and Steel Production (2C1)

The CO_2 emissions from iron and steel production (2C1) were calculated by using the Tier 1 method in accordance with the decision tree of the 2006 IPCC Guidelines (Vol. 3, page 4.20, Fig. 4.7), and the decision tree of the 2006 IPCC Guidelines (Vol. 3, page 4.20, Fig. 4.8) was used for estimation of CH_4 emissions. Iron and steel production in Thailand employs Electric Arc Furnaces (EAF). CO_2 emissions from Iron and Steel production (2C1) were estimated by using Eq.4.4 in the 2006 IPCC Guidelines (Vol. 3, page 4.21, Eq.4.4)

EQUATION 4.4
CO_2 EMISSIONS FROM IRON AND STEEL PRODUCTION (TIER 1)

$$\text{Iron \& Steel: } E_{CO2,\,non-energy} = BOF \bullet EF_{BOF} + EAF \bullet EF_{EAF} + OHF \bullet EF_{OHF}$$

Where:

$E_{CO2,\,non\text{-}energy}$ = emissions of CO_2 to be reported in IPPU Sector, tonnes

BOF = quantity of BOF crude steel produced, tonnes

EAF = quantity of EAF crude produced, tonnes

OHF = quantity of OHF crude steel produced, tonnes

EF = emission factor

Activity Data of Iron and Steel Production (2C1)

The activity data for Iron and Steel Production (2C1) were obtained from the Iron and Steel Institute of Thailand in the form of annual reports. Table 2-83 presents activity data of steel production for 2020, 2021 and 2022 after 2019, as reported in the BUR4.

Table 2-83: Activity data of Steel Production (2C1) for 2020-2022

Year	Physical unit	Iron and steel production
2020	tonne	4,467,220.00
2021	tonne	5,472,928.27
2022	tonne	5,316,446.96

Emission Factors of Iron and Steel Production (2C1)

The emission factors employed in calculating greenhouse gas emissions in Iron and Steel Production (2C1) follow the default values of the 2006 IPCC Guidelines. For Electric Arc Furnaces used in steelmaking, an emission factor of 0.08 tonne CO_2 per tonne of steel produced from 2006 IPCC Guidelines (Vol 3, Page 4.25, Table 4.1) was employed. (Table 2-84)

Table 2-84: CO_2 emission factors of Iron and Steel Production (2C1) for 2000-2021

Parameter	Value
Emission factor (EF)	0.08 tonne CO_2/tonne steel

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of Iron and Steel Production (2C1), the uncertainties indicated in the 2006 IPCC Guidelines (-25% to +25% for CO_2) were adopted. Since the values in the annual reports of Ministry of Industry were used for the activity data, the default values in the 2006 IPCC Guidelines (-10% to +10%) were adopted for the uncertainty of activity data (see 2006 IPCC Guidelines Vol 3, Page 4.30, Table 4.4). Therefore, the uncertainty of the emissions from Thailand's Iron and Steel Production was estimated as 10% to 25%

TABLE 4.4
UNCERTAINTY RANGES

Method	Data Source	Uncertainty Range
Tier 1	Default Emission Factors	± 25%
	National Production Data	± 10%
Tier 2	Material-Specific Default Carbon Contents	± 10%
	National Reducing Agent & Process Materials Data	± 10%
Tier 3	Company-Derived = Process Materials Data	± 5%
	Company-Specific Measured CO_2 and CH_4 Data	± 5%
	Company-Specific Emission Factors	± 5%

Time-series Consistency

The data of iron and steel production given in the annual report of the Iron and Steel Institute of Thailand are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported. This flexibility is used in light of domestic capacities, in accordance with the MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex), paragraph 57.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking the parameters for activity data and emission factors and the archiving of reference materials. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

No planned improvements in Metal Production (2C).

Emissions from Iron and Steel Production (2C1)

CO_2 Emission from Iron and Steel Production (2C1)

The estimated CO_2 emissions from Iron and Steel Production (2C1) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-85. The time series of total emissions from 2000 to 2022 is shown in Figure 2-49. The trend of total emissions from Iron and Steel Production (2C1) has increased since 2000. Total CO_2 emissions are estimated at 357.38, 437.83 and 425.32 $ktCO_2eq$ in 2020, 2021 and 2022, respectively.

Table 2-85: Estimated CO_2 emissions from Iron and Steel Production (2C1) for 2020-2022

Year	CO_2 emissions ($ktCO_2$)
2020	357.38
2021	437.83
2022	425.32

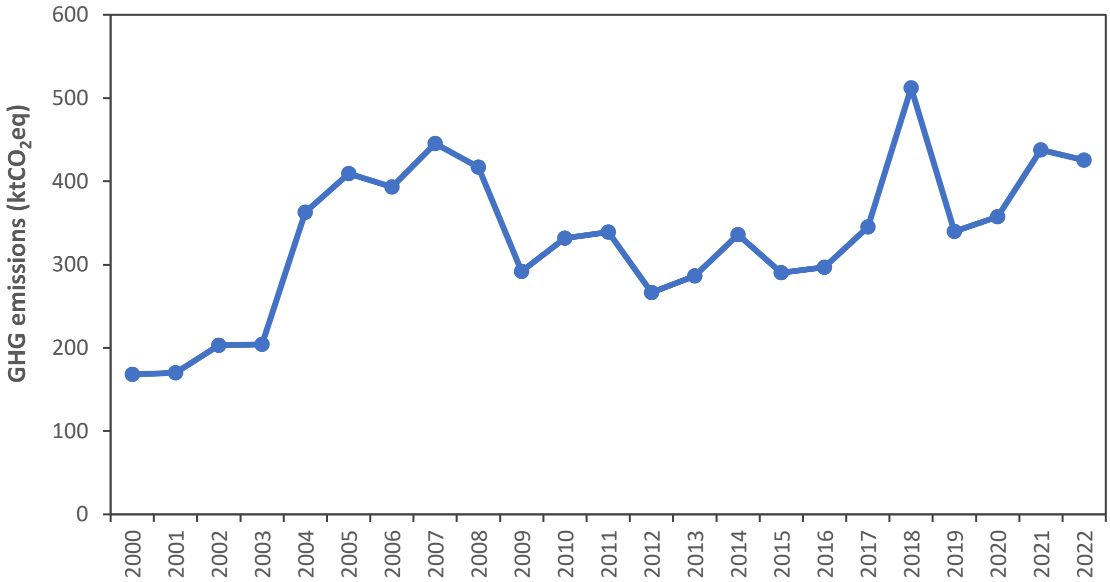


Figure 2-49: CO_2 emission from Iron and Steel Production (2C1) for 2000-2022

Non-Energy Products from Fuels and Solvent Use (2D)

Category Description

This section provides the estimation methods for CO_2 emissions Non-Energy Products from Fuels and Solvent Use (2D), which includes only Lubricant Use (2D1). (Figure 2-50)

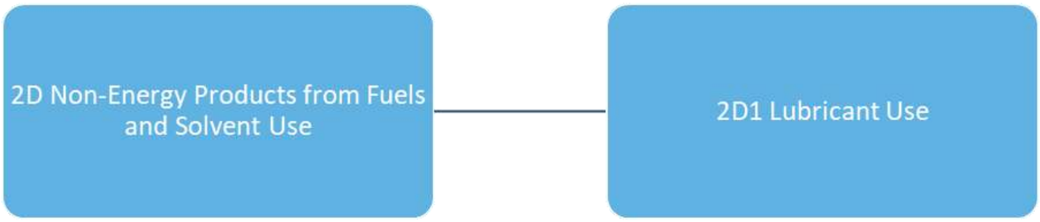


Figure 2-50: Emissions sources of Non-Energy Products from Fuels and Solvent Use (2D) in Thailand for 2000-2022

Estimation Method

The CO_2 emissions from Non-Energy Products from Fuels and Solvent Use (2D) were calculated by using the Tier 1 method in accordance with the decision tree of the 2006 IPCC Guidelines (Vol. 3, page 5.7, Fig. 5.1). CO_2 emissions from Lubricant Use (2D1) were estimated by using Eq.5.2 of 2006 IPCC Guidelines (Vol. 3, page 5.7, Eq.5.2)

EQUATION 5.2
LUBRICANTS – TIER 1 METHOD

$$CO_2\ Emissions = LC \bullet CC_{Lubricant} \bullet ODU_{Lubricant} \bullet 44/12$$

Where:

CO_2 *Emissions* = CO_2 emissions from lubricants, tonne CO_2

LC = total lubricant consumption, TJ

$CC_{Lubricant}$ = carbon content of lubricants (default), tonne C/TJ (= kg C/GJ)

$ODU_{Lubricant}$ = ODU factor (based on default composition of oil and grease)

Activity Data of Lubricant Use (2D1)

The Department of Energy Business provided activity data of lubricant use in Thailand. The Activity data for Lubricant Use (2D1) for 2020-2022 are presented in Table 2-86.

Table 2-86: Activity data of Lubricant Use (2D1) for 2020-2022

Year	Physical unit	Lubricant use
2020	million liters	584.08
2021	million liters	608.54
2022	million liters	620.63

Emission Factors of Lubricant Use (2D1)

The emission factors employed in calculating greenhouse gas emissions from Lubricant Use (2D1) follow the default values of the 2006 IPCC Guidelines. The ODU factor of 0.2 was selected from 2006 IPCC Guidelines (Vol. 3, page 5.9, Table 5.2). The NCV of 40.2 TJ/Gg from 2006 IPCC Guidelines (Vol 2, Table 1.2) was employed for lubricant using a specific gravity of lubricant of 0.8 g/ml. Table 2-87 presents emission factors of Lubricant Use (2D1) for 2000-2022.

TABLE 5.2
DEFAULT OXIDATION FRACTIONS FOR LUBRICATING OILS, GREASE AND LUBRICANTS IN GENERAL

Lubricant / type of use	Default fraction in total lubricant [a] (%)	ODU factor
Lubricating oil (motor oil /industrial oils)	90	0.2
Grease	10	0.05
IPCC Default for total lubricants [b]		**0.2**

Table 2-87: Emission factor of Lubricant Use (2D1) for 2000-2022

Parameter	Value
Emission factor (EF)	20.0 tonne C/TJ

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of Lubricant Use (2D1), the uncertainties indicated in the 2006 IPCC Guidelines (50% for CO_2) were adopted. Since the values in the annual reports were used for the activity data, the default values in the 2006 IPCC Guidelines (5% to 20%) were adopted for the uncertainty of activity data. Therefore, the uncertainty of the emissions from Thailand's Lubricant Use (2D1) was estimated as 5% to 50%.

Time-series Consistency

The data of Lubricant Use (2D1) given in the annual reports are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported. This flexibility is used in light of domestic capacities, in accordance with the MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex), paragraph 57.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking the parameters for activity data and emission factors and the archiving of reference materials. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

No planned improvements for Non-Energy Products from Fuels and Solvent Use (2D).

Emissions from Lubricant Use (2D1)

CO_2 Emission from Lubricant Use (2D1)

The estimated CO_2 emissions from Lubricant Use (2D1) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-88. Total CO_2 emissions are estimated at 275.50, 287.04 and 292.74 ktCO_2eq in 2020, 2021 and 2022, respectively. The time series of total emissions from 2000 to 2022 is shown in Figure 2-51. The trend of total emissions from Iron and Steel Production (2C1) has increased from 218.93 ktCO_2 in 2000 to 292.74 ktCO_2 in 2022.

Table 2-88: Estimated CO_2 emissions from Iron and Steel Production (2C1) for 2020-2022

Year	CO_2 emissions (ktCO_2)
2020	275.50
2021	287.04
2022	292.74

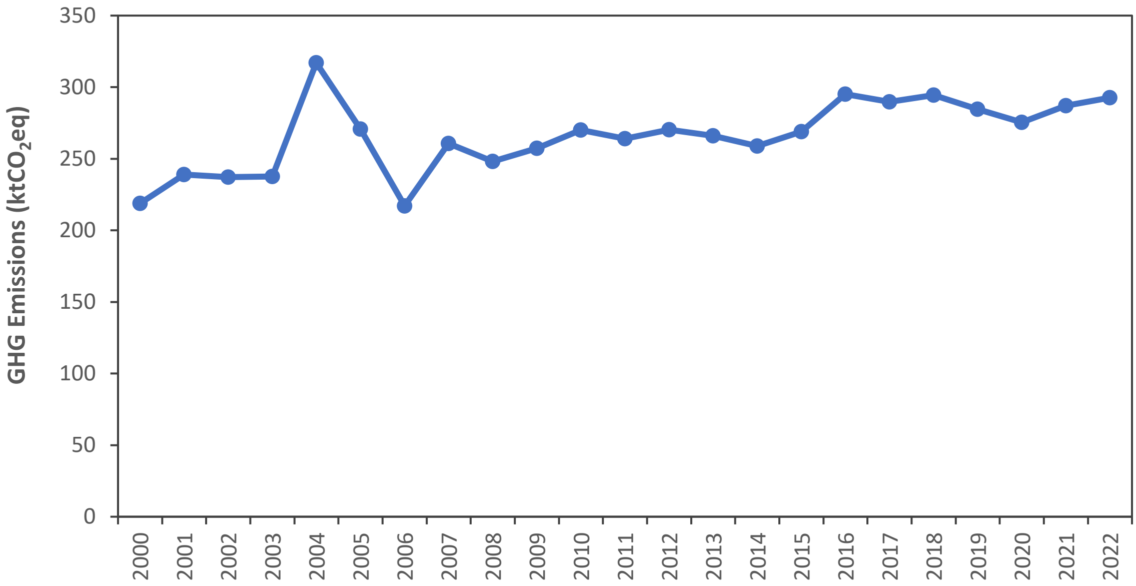


Figure 2-51: CO_2 emission from Lubricant Use (2D1) for 2000-2022.

Product Uses as Substitutes for Ozone Depleting Substances (2F)

Category Description

This section provides the estimation methods for emissions in Thailand from Product Uses as Substitutes for Ozone Depleting Substances (2F), which includes only Refrigeration and Air Conditioning (2F1) (Figure 2-52).

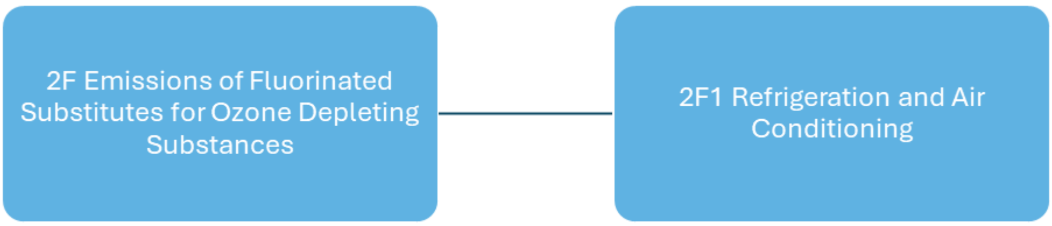


Figure 2-52: Emissions sources of Non-Energy Products from Fuels and Solvent Use (2D) in Thailand for 2000-2022

Estimation Method for Refrigeration and Air Conditioning (2F1)

The emissions from Refrigeration and Air Conditioning (2F1) were calculated by using the Tier 1 method in accordance with Table 7.2 of the 2006 IPCC Guidelines (Vol. 3, page 7.13, Table 7.2). Emissions from Refrigeration and Air Conditioning (2F1) were estimated by using Eq.7.1 and Eq. 7.2A of 2006 IPCC Guidelines (Vol. 3, page 7.14, Eqs.7.1 and 7.2A)

The calculation formula for Net Consumption within the Tier 1a method is as follows:

EQUATION 7.1
CALCULATION OF NET CONSUMPTION OF A CHEMICAL IN A SPECIFIC APPLICATION

$$Net\ Consumption = Production + Imports - Exports - Destruction$$

Net Consumption values for each HFC or PFC are then used to calculate annual emissions for application exhibiting prompt emissions as follows:

EQUATION 7.2A
CALCULATION OF EMISSIONS OF A CHEMICAL FROM A SPECIFIC APPLICATION

$$Annual\ Emissions = Net\ Consumption \bullet Composite\ EF$$

Where:

Net consumption = net consumption for the application
Composite EF = composite emission factor for the application

Activity Data of Refrigeration and Air Conditioning (2F1)

The import and export of refrigerants were provided by the Department of Industrial Works Ministry of Industry. The activity data of Refrigeration and Air Conditioning (2F1) for 2020, 2021 and 2022 after 2019, as reported in the BUR4, are presented in Table 2-89.

Table 2-89: Activity Data of Refrigeration and Air Conditioning (2F1) from 2020-2022

Year	Net Consumption, kilo- tonne of Refrigerants						Total
	HFC-134a	HFC-23	HFC-143a	HFC-32	HFC-152a	HFC-125	
2020	6.96	0.01	0.28	15.41	0.18	7.80	30.64
2021	6.25	0.01	0.65	18.39	0.23	9.36	34.89
2022	11.30	0.01	1.72	23.13	0.24	9.59	45.99

Emission Factors of Refrigeration and Air Conditioning (2F1)

From Eq.7.2A of 2006 IPCC Guidelines (Vol. 3, page 7.14, Eq.7.2A), the term composite emission factor refers to an emissions rate that summarises the emission rates of different types of equipment, product or, more generally, sub-applications within an ODS application area. Composite emission factors account for assembly, operation and, where relevant in the time series, disposal emissions. The composite EF of 0.15 was employed. The GWP from IPCC-AR5 was used to convert HFCs to CO_2 equivalent. (Table 2.90)

Table 2-90: GWP from IPCC Fifth Assessment Report

Type of F-gases	Global Warming Potential (GWP) AR5
HFC-23	12,400
HFC-125	3,170
HFC-134a	1,300
HFC-143a	4,800
HFC-152a	138

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of Refrigeration and Air Conditioning (2F1), the uncertainties indicated in the 2006 IPCC Guidelines (99% for HFCs) were adopted. Since the values in the annual reports were used for the activity data, the default values in the 2006 IPCC Guidelines (-99%) were adopted for the uncertainty of activity data. Therefore, the uncertainty of the emissions from Refrigeration and Air Conditioning (2F1) was estimated as high as 99% for HFCs.

Time-series Consistency

The data of Refrigeration and Air Conditioning (2F1) given in the annual reports are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported. This flexibility is used in light of domestic capacities, in accordance with the MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex), paragraph 57.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking the parameters for activity data and emission factors and the archiving of reference materials. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

The composite emissions estimated for F-gases follow IPCC default value. However, capacity building and support are needed to adopt a higher tier method including disaggregate activity data. The Tier 2 approach, in accordance with the good practice elaborated in the IPCC guidelines, is planned, and proposed to implement before the next submission.

Emissions from Product Uses as Substitutes for Ozone Depleting Substances (2F)

HFCs Emission from Refrigeration and Air Conditioning (2F1)

The consumption of refrigerants in Thailand includes HFC-23, HFC-32, HFC-125, HFC-134a, HFC-143a, and HFC-152a. The estimated HFCs emissions from Refrigeration and Air Conditioning (2F1) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-91. Total CO_2eq emissions are estimated at 6,849.58, 8,020.89 and 10,383.15 ktCO_2eq in 2020, 2021 and 2022, respectively. The time series of total emissions from 2000 to 2022 is shown in Figure 2-53. The trend of HFCs emissions from Refrigeration and Air Conditioning (2F1) has drastically increased from 40.32 ktCO_2eq in 2000 to 10,383.15 ktCO_2eq in 2022.

Table 2-91: HFCs Emissions from Refrigeration and Air Conditioning (2F1) from 2020-2022

Year	HFCs Emissions (ktCO_2eq)						Total (ktCO_2eq)
	HFC-134a	HFC-23	HFC-143a	HFC-32	HFC-152a	HFC-125	
2020	1,356.65	17.90	198.60	1,564.86	3.78	3,707.79	6,849.58
2021	1,219.31	9.98	469.64	1,867.99	4.66	4,449.31	8,020.89
2022	2,202.75	25.25	1,239.42	2,349.19	4.89	4,561.65	10,383.15

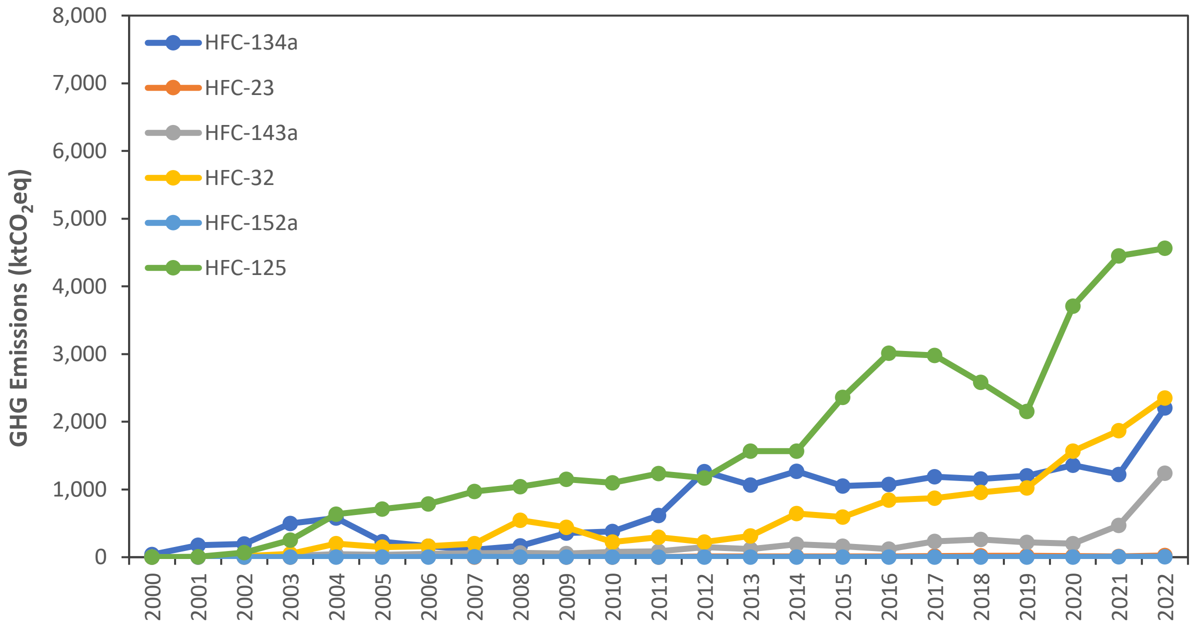


Figure 2-53: HFCs Emission from Refrigeration and Air Conditioning (2F1) for 2000-2022

Other Product Manufacture and Use (2G)

Category Description

This section provides the estimation methods for emissions from Other Product Manufacture and Use (2G) in Thailand, which includes only Electrical Equipment (2G1) (Figure 2-54).

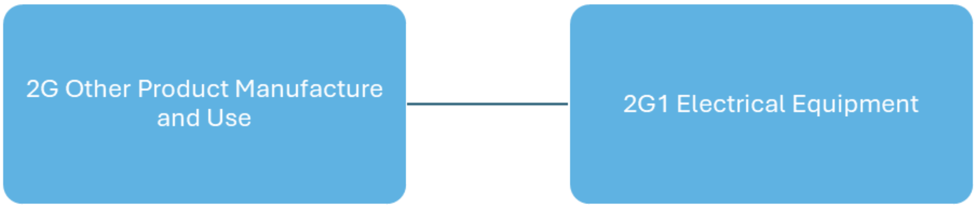


Figure 2-54: Emissions sources of Other Product Manufacture and Use (2G) in Thailand

Estimation Method for Electrical Equipment (2G1)

The SF_6 emissions from Electrical Equipment (2G1) were calculated by using the Tier 1 method in accordance with the decision tree of the 2006 IPCC Guidelines (Vol. 3, page 8.8, Fig. 8.1). SF_6 emissions from Electrical Equipment (2G1) were estimated by using Eq.8.1 of 2006 IPCC Guidelines (Vol. 3, page 8.8, Eq.8.1)

EQUATION 8.1
DEFAULT EMISSION FACTOR METHOD

Total Emissions = Manufacturing Emissions + Equipment Installation Emissions + Equipment Use Emissions + Equipment Disposal Emissions

Where:

Manufacturing emissions	=	Manufacturing emission factor * Total SF_6 consumption by equipment manufacturers
Equipment installation emissions	=	Installation emission factor * Total nameplate capacity of new equipment filled on site (not at the factory).
Equipment use emissions	=	Use emission factor * Total nameplate capacity of installed equipment. The 'use emission factor' includes emissions due to leakage, servicing, and maintenance as well as failures
Equipment disposal emissions	=	Total nameplate capacity of retiring equipment * Fraction of SF_6 remaining at retirement

Activity Data of SF_6 from Electrical Equipment (2G1)

The Department of Industrial Works under the Ministry of Industry collects data of SF_6 used in electrical equipment in the form of annual reports. (Table 2-92)

Table 2-92: Activity data of Electrical Equipment (2G1) for 2020-2022

Year	Physical unit	Use of SF_6
2020	tonne	0.06
2021	tonne	0.09
2022	tonne	0.11

Emission Factors of SF_6 from Electrical Equipment (2G1)

The emission factors employed in calculating SF_6 from Electrical Equipment (2G1) follow the default values of the 2006 IPCC Guidelines of National Greenhouse Gas Inventories. An emission factor of 0.29 of gas insulated transformers containing SF_6 from 2006 IPCC Guidelines (Vol 3, Page 8.16, Table 8.4) was used in estimation of emissions with a Global Warming Potential (GWP) value of SF_6 of 23,500 (Table 2-93).

TABLE 8.4
GAS INSULATED TRANSFORMERS CONTAINING SF_6: DEFAULT EMISSION FACTORS

Phase / Region	Manufacturing (Fraction SF_6 Consumption by Manufacturers)	Use (Includes leakage, major failures/arc faults and maintenance losses) (Fraction per Year of Nameplate Capacity of All Equipment Installed)	Disposal (Fraction Nameplate Capacity of Disposed Equipment)	
			Lifetime (years)	Fraction of charge remaining at retirement [a]
Japan [b]	0.29	0.007	Not reported	0.95

Table 2-93: GWP of SF_6 from IPCC AR5

Parameter	Value
GWP of SF_6	23,500

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of Electrical Equipment (2G1), the uncertainties indicated in the 2006 IPCC Guidelines (-30% to +30% for SF_6) were adopted. Since the values in the annual report were used for the activity data, the default values in the 2006 IPCC Guidelines (-10% to +40%) were adopted for the uncertainty of activity data. Therefore, the uncertainty of the emissions from Thailand's Electrical Equipment (2G1) was estimated as -30% to +30% for SF_6.

Time-series Consistency

The data of Electrical Equipment (2G1) given in the annual report are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported. This flexibility is used in light of domestic capacities, in accordance with the MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex), paragraph 57.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking the parameters for activity data and emission factors and the archiving of reference materials. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

Emissions estimated for Electrical Equipment (2G1) follow the Tier 1 approach. However, capacity building and support are needed to adopt a higher tier method. The Tier 2 approach, in accordance with the good practice elaborated in the IPCC Guidelines is planned, and proposed to implement before the next submission.

Emissions from Other Product Manufacture and Use (2G)

SF_6 Emissions from Electrical Equipment (2G1)

The estimated SF_6 Emissions from Electrical Equipment (2G1) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-94. Total SF_6 Emissions are estimated at 410.26, 596.31 and 756.09 $ktCO_2eq$ in 2020, 2021 and 2022, respectively. The time series of SF_6 emissions from 2000 to 2022 is shown in Figure 2-55. The trend of SF_6 emissions from Electrical Equipment (2G1) in Thailand drastically increased from 63.05 $ktCO_2eq$ in 2020 to 756.09 $ktCO_2eq$ in 2022.

Table 2-94: SF_6 emissions from Electrical Equipment (2G1) for 2020-2022

Year	SF_6 emissions (kt)	Emissions ($ktCO_2eq$)
2020	0.02	410.26
2021	0.03	596.31
2022	0.03	756.09

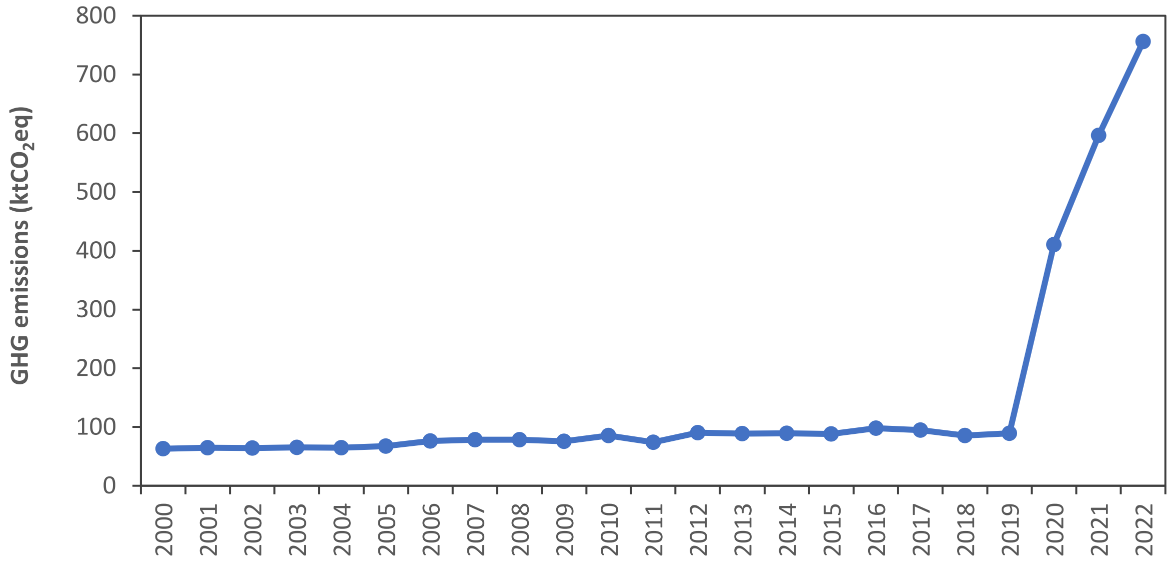


Figure 2-55: SF_6 Emissions from Electrical Equipment (2G1) for 2000-2021

Other (2H)

Category Description

This section provides the estimation methods for emissions from Other (2H) in Thailand, which includes Pulp and Paper (2H1), and Food and Beverage (2H2). (Figure 2-56)

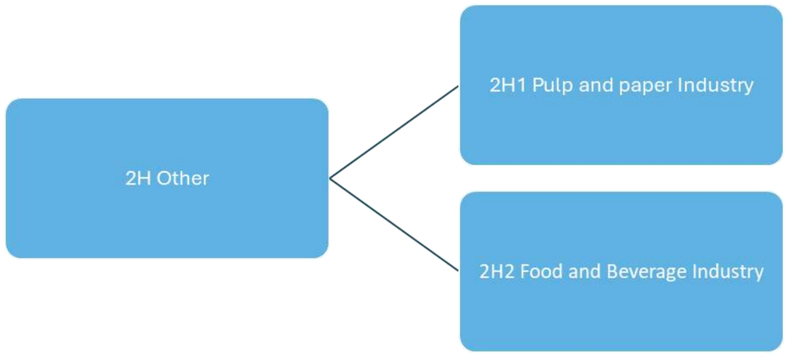


Figure 2-56: Emissions sources of Non-Energy Products from Fuels and Solvent Use (2D) in Thailand for 2000-2022

Estimation Method for Pulp and Paper (2H1) and Food and Beverage (2H2)

These processes do not produce carbon dioxide gas, but they do emit sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and non-methane volatile organic compounds (NMVOCs). The estimation method of these gases follows Tier 1 of the 2006 IPCC Guidelines. However, only emission factors of carbon monoxide, nitrogen oxides, non-methane volatile organic compounds, and sulfur dioxide were obtained from the 1996 IPCC Guideline of National Greenhouse Gas Inventories.

Activity Data of Pulp and Paper (2H1)

The activity data of Pulp and Paper (2H1) were provided by Department of Industrial Economics in terms of annual production, and are presented in Table 2-95.

Table 2-95: Activity data of Pulp and Paper (2H1) for 2022

Year	Physical unit	Pulp and Paper Production
2020	tonne	966,287.00
2021	tonne	992,733.43
2022	tonne	880,066.00

Activity Data of Food and Beverage (2H2)

Annual reports of Food and Beverage (2H2) were used as activity data. The activity data of beer, alcohol, animal feed, cake, sugar, and meat were provided by the Office of Industrial Economics. The activity data of wine were provided by the Excise Department. The activity data of roasted coffee were provided by the Office of Agricultural Economics. (Table 2-96)

Table 2-96: Activity data of Food and beverage (2H2) for 2020-2022

Year	Food production (tonne)				
	Meat	Sugar	Cake	Animal feed	Roasted Coffee
2020	1,429,692.29	10,585,653.38	322,537.63	17,535,705.50	22,835.92
2021	5,187,220.27	11,637,186.25	48,064.66	12,925,899.00	21,773.00
2022	4,178,938.00	13,214,523.00	46,925.00	12,586,571.00	0

Year	Beverage (Liter)		
	Wine	Beer	Alcohol
2020	398,639.30	382,190.11	21,758,615.51
2021	447,632.19	21,043,938.50	3,542,507.58
2022	465,311.77	23,589,237.10	2,935,381.44

Emission Factors of Pulp and Paper (2H1)

There were no direct CO_2 emissions from Other (2H). Only indirect emissions, i.e. NO_x, CO, NMVOCs and SO_2 were estimated. Emission factors employed in calculating these emissions from Pulp and Paper (2H1) follow the default values of the 1996 IPCC Guidelines of National Greenhouse Gas Inventories (Vol 2, Page 2.39, Table 2-23).

TABLE 2-23 NON-COMBUSTION EMISSION FACTORS FOR PULP AND PAPER PRODUCTION KRAFT PULPING (KG/TONNE DRIED PULP)		
Pollutant	Emission Factor (Default)	Emission Factor (Range)
NO_x	1.5	0.017-1.5
NMVOC	3.7	0.1-4.9
CO*	5.6	NAV
SO_2	7	0.005-10
Ref: US EPA 1995. NAV = Not Available		

In this report, Table 2-97 presents emission factors of Pulp and Paper (2H1) for the estimated emissions in Thailand.

Table 2-97: Emission factors of Pulp and Paper (2H1) for 2000-2022

Type of gas	Emission Factor (kg/tonne dried pulp)*
CO_2	-
NO_x	1.5
NMVOC	3.7
CO	5.6
SO_2	7

Note: *The 1996 IPCC Guidelines of National Greenhouse Gas Inventories

Emission Factors of Food and Beverage (2H2)

There were no direct CO_2 emissions from Food and Beverage (2H2). Only NMVOC emissions were estimated. Emission factors employed in calculating NMVOC emissions from Food and Beverage (2H2) follow the default values of the 1996 IPCC Guidelines of National Greenhouse Gas Inventories (Vol 2, Page 2.41, Table 2-25) and (Vol 2, Page 2.42, Table 2-26).

TABLE 2-25 EMISSION FACTORS FOR NMVOC FROM ALCOHOLIC BEVERAGE PRODUCTION (KG/HL BEVERAGE)	
Beverage	Emission Factor
Wine	0.08
Red wine	0.08
White wine	0.035
Beer	0.035
Spirits (unspecified)	15
Malt whiskey	15
Grain whiskey	7.5
Brandy	3.5
Note: hl = 100 litres	

TABLE 2-26 EMISSION FACTORS FOR NMVOC FROM BREAD AND OTHER FOOD PRODUCTION (KG/TONNE)	
Food Production Process	Emission Factor
Meat, fish and poultry	0.3
Sugar	10
Margarine and solid cooking fats	10
Cakes, biscuits and breakfast cereals	1
Bread	8
Animal feed	1
Coffee roasting	0.55

In this report, Table 2-98 presents emission factors of Food and Beverage (2H2) for the estimated emissions in Thailand.

Table 2-98: NMVOCs emission factors of Food and Beverage (2H2) for 2000-2022

Type of Emission Factor	Emission Factor
Wine	0.08 kg/HL beverage
Beer	0.035 kg/HL beverage
Spirits	15 kg/HL beverage
Grain whiskey	-
Meat, fish and poultry	0.3 kg/HL beverage
Sugar	10 kg/tonnes
Cakes, biscuits and breakfast cereals	1 kg/tonnes
Animal feed	1 kg/tonnes
Coffee roasting	0.55 kg/tonnes

Note: HL = 100 litres.

Time-series Consistency

The data of Other (2H) given in the annual reports are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported. This flexibility is used in light of domestic capacities, in accordance with the MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1 Annex), paragraph 57.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking the parameters for activity data and emission factors and the archiving of reference materials. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

No planned improvements in Other (2H)

Emissions from Pulp and Paper Production (2H1)

Indirect Emissions from Pulp and Paper Production (2H1)

There were no direct CO_2 emissions from Pulp and Paper Production (2H1). Only indirect emissions, i.e. NO_x, CO, NMVOCs and SO_2 were estimated, and are presented in Table 2-99. These emissions slightly increased in 2022 compared to their level in 2000. For CO, emissions increased from 3.81 kt in 2000 to 4.93 kt in 2022. For NO_x, emissions increased from 1.02 kt in 2000 to 1.32 kt in 2022. For NMVOC, emissions increased from 2.51 kt in 2000 to 3.26 kt in 2022. For SO_2, emissions increased from 4.76 kt in 2000 to 6.16 kt in 2022. (Figure 2-57)

Table 2-99: Indirect emissions from Pulp and Paper Production (2H1) for 2020-2022

Year	CO (kt)	NO_x (kt)	NMVOC (kt)	SO_2 (kt)
2020	5.41	1.45	3.58	6.76
2021	5.56	1.49	3.67	6.95
2022	4.93	1.32	3.26	6.16

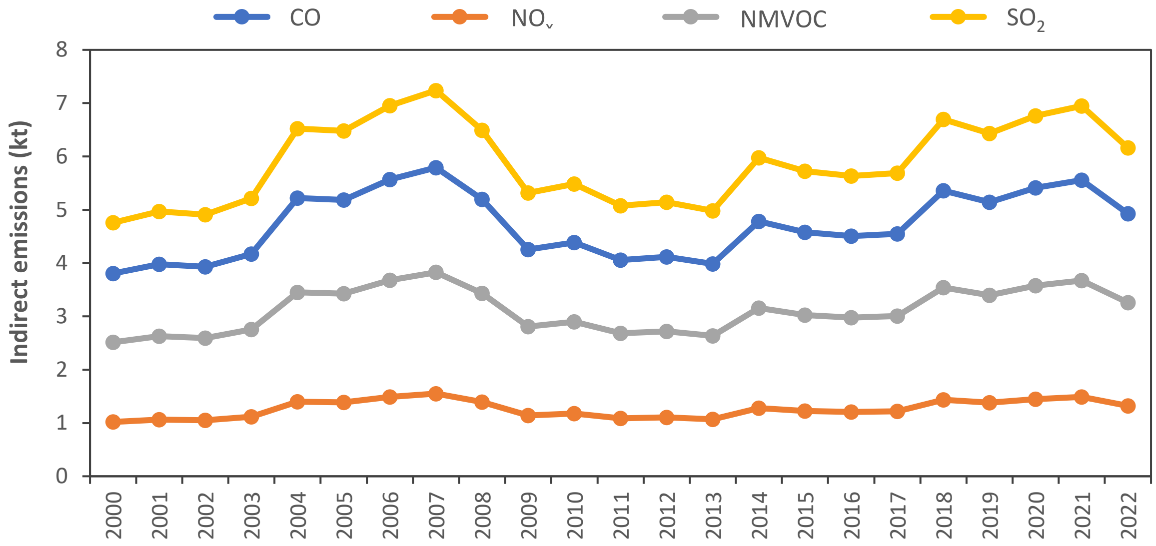


Figure 2-57: Indirect emissions from Pulp and Paper Production (2H1) for 2000-2022

NMVOC Emissions from Food and Beverage (2H2)

There were no direct CO_2 emissions from Food and Beverage (2H2). Only NMVOC emissions were estimated. The estimated NMVOC emissions from Food and Beverage (2H2) for 2020, 2021 and 2022 after 2019, as reported in BUR4, are presented in Table 2-100. The trend of NMVOC emissions from Food and Beverage (2H2) increased from 99.67 kt in 2000 to 190.92 kt in 20222. However, due to COVID-19 lockdowns by Thailand in 2020, NMVOC emissions from Food and Beverage (2H2) increased to 450.58 kt. (Figure 2-58)

Table 2-100: NMVOC Emissions from Food and Beverage (2H2) for 2020-2022

Year	NMVOC (kt)
2020	450.58
2021	184.84
2022	190.92

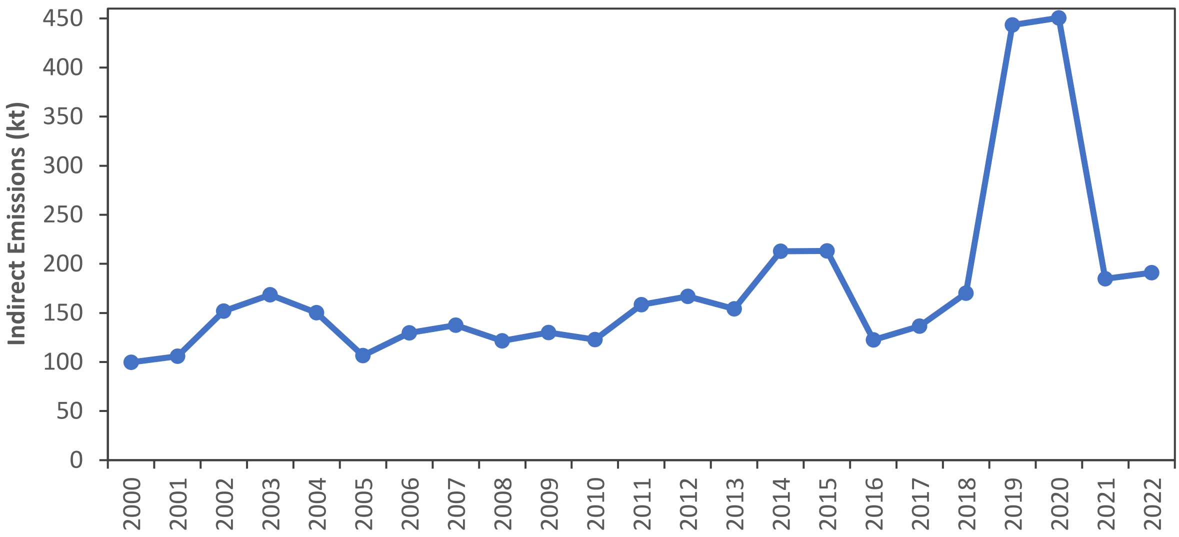


Figure 2-58: NMVOC emissions from Food and Beverage (2H2) for 2000-2022

2.3 AGRICULTURE SECTOR

Description of methods and data sources used

In this inventory, the estimation of greenhouse gas (GHG) emissions from the Agriculture sector follows the 2006 IPCC Guidelines, which categorize emissions into nine specific areas: Enteric Fermentation (3A1), Manure Management (3A2), Biomass Burning in Cropland or Field Burning of Agricultural Residues (3C1b), Liming (3C2), Urea Fertilization (3C3), Direct N_2O Emissions from Managed Soils (3C4), Indirect N_2O Emissions from Managed Soils (3C5), Indirect N_2O Emissions from Manure Management (3C6), and Rice Cultivation (3C7).

The methodology tiers were chosen based on the decision trees provided in the 2006 IPCC Guidelines, utilizing both Tier 1 and Tier 2 methods for the agriculture sector. Activity data were obtained from published reports from relevant government agencies within the Ministry of Agriculture and Cooperatives. Contributions to this data came from various agencies, including the Office of Agricultural Economics, the Department of Livestock Development, the Office of the Cane and Sugar Board, the Department of Agriculture, the Rice Department, the Land Development Department, the Department of Agricultural Extension, and the Geo-Informatics and Space Technology Development Agency (Public Organization). Additionally, supporting data for estimating Tier 2 emission factors were sourced from national publications, expert judgment, and IPCC default values. The emission factors used consist of both country-specific data and the 2006 IPCC defaults. (Table 2-101)

The reporting of GHGs—specifically CO_2, CH_4, and N_2O—was based on the Global Warming Potential (GWP) values outlined in the IPCC Fifth Assessment Report (AR5). Over a 100-year period, the GWP values for CH_4 and N_2O are 28 and 265 times that of CO_2, respectively. The assessment of GHG emissions in the agriculture sector relies on the identification of emission sources, the calculation methodologies applied, and the emission factors used, as further explained in the subsequent sections.

Table 2-101: Summary of methods and emission factors (Sectors: Agriculture)

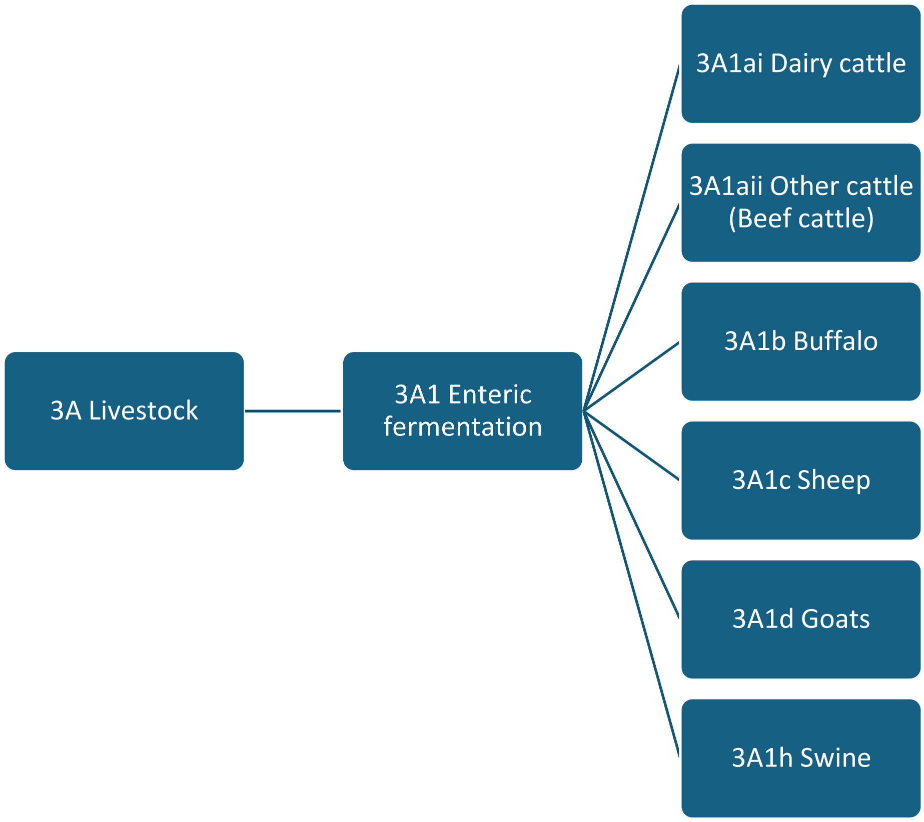
GHG source and sink categories	CO_2		CH_4		N_2O		NO_x		CO		NMVOCs		SO_2		HFCs		PFCs		SF_6	
	Method applied	EF	Method applied	EF	Method applied	EF	Method applied	EF	Method applied	EF	Method applied	EF	Method applied	EF	Method applied	EF	Method applied	EF	Method applied	EF
3. Agriculture	T1	D	T1, T2	CS, D	T1, T2	D	T1	D	T1	D										
3A Enteric Fermentation			T1, T2	CS, D																
3B Manure Management			T1, T2	CS, D	T2	D														
3C Field Burning of Agricultural Residues			T1	D	T1	D	T1	D	T1	D										
3D Liming	T1	D																		
3E Urea Fertilization	T1	D																		
3F Direct N_2O Emission from Managed Soils					T1	D														
3G Indirect N_2O Emission from Managed Soils					T1	D														
3H Indirect N_2O Emission from Manure Management					T2	D														
3I Rice Cultivation			T2	CS																

Note: T2: IPCC Tier 2, T1: IPCC Tier 1, EF: Emission factor, CS: Country specific and D: IPCC default.

Enteric fermentation (3A1)

Category Description

Livestock is categorized into groups such as ruminants, monogastric animals, and poultry, among others. Each group has distinct feeding and management practices due to differences in physiology, dietary needs, and growth rates. Ruminants, in particular, have a digestive system that significantly affects GHG emissions compared to other animal groups. Enteric fermentation in these animals releases CH_4.



Estimation Method

The assessment level chosen for calculating greenhouse gas emissions depends on the availability of activity data and other supporting information. For key livestock groups that have high CH_4 emissions, such as dairy cattle, beef cattle, and buffalo, a Tier 2 assessment can be conducted. This involves collecting detailed population data categorized by species, gender, and age. Information was gathered from research and experts within the Department of Livestock Development to calculate country-specific emission factors using equations provided by 2006 IPCC GLs. For other species, such as pigs, poultry, sheep, and goats, which have lower CH_4 emissions, a Tier 1 assessment was utilized.

$$\text{Emissions} = EF_{(T)} \times N_{(T)} \times 10^{-6} \quad (3A1\text{-}1)$$

$$\text{Total } CH_{4\ Enteric} = \sum(\text{Emissions}) \quad (3A1\text{-}2)$$

Where:

Emissions = methane emissions from Enteric Fermentation (Gg CH_4/year)
$EF_{(T)}$ = emission factor for the defined livestock population (kg CH_4/head/year)
$N_{(T)}$ = the number of head of livestock species / category T in the country
Total $CH_{4\ Enteric}$ = total methane emissions from Enteric Fermentation (Gg CH_4/year)

$$EF = \frac{GE \times \left(\frac{Y_m}{100}\right) \times 365}{55.65} \quad (3A1\text{-}3)$$

Where:

EF = emission factor (kg CH_4/head/year)
GE = gross energy intake (MJ/head/day)
Y_m = methane conversion factor (%)
365 = time conversion (days/year)
55.65 = energy content of methane

$$GE = \left(\frac{NE_m + NE_a + NE_l + NE_{work} + NE_p}{REM} + \left(\frac{NE_g + NE_{wool}}{REG} \right) \right) \times \left(\frac{100}{DE\%} \right) \quad (3A\text{-}4)$$

Where:

NE_m = net energy required by the animal for maintenance (MJ/day):
NE_m for cattle/buffalo (non-lactating cows) = 0.322 × $(weight)^{0.75}$
NE_m for cattle/buffalo (lactating cows) = 0.386 × $(weight)^{0.75}$
NE_m for cattle/buffalo (bull) = 0.370 × $(weight)^{0.75}$
Note: weight = live-weight of animal (kg)

NE_a = net Energy for Animal Activity (MJ/day):
NE_a for cattle/buffalo (stall) = 0 × NE_m
NE_a for cattle/buffalo (pasture) = 0.17 × NE_m
NE_a for cattle/buffalo (grazing large areas) = 0.36 × NE_m

NE_l = net Energy for Lactation (MJ/day):
NE_l for beef cattle, dairy cattle and buffalo = milk × (1.47 + 0.40 × fat)
note: milk = amount of milk produced (kg of milk/day)
fat = fat content of milk (% by weight)

NE_{work} = net Energy for Work (MJ/day):
NE_{work} = 0.10 × NE_m × Hours (note: Hours = number of hours of work per day)

NE_p = net Energy for Pregnancy (MJ/day):
NE_p for cattle and buffalo = 0.10 × NE_m

NE_g = net Energy for Growth (MJ/day):
NE_g for cattle and buffalo = $22.02 \times \left(\frac{BW}{C \times MW}\right)^{0.75} \times WG^{1.097}$
note: C = 0.8 for females, 1.0 for castrates and 1.2 for bulls
BW = the average live body weight of the animals in the population (kg)
MW = the mature live body weight of an adult female in moderate body condition (kg)
WG = the average daily weight gain of the animals in the population (kg/day)

NE_{wool} = net Energy to Produce Wool (for sheep) (MJ/day)

REM = ratio of net energy available in a diet for maintenance to digestible energy consumed

$REM = 1.123 – (4.092 \times 10^{-3} \times DE\%) + (1.126 \times 10^{-5} \times DE\%^2) – (25.4/DE\%)$

REG = ratio of net energy available for growth in a diet to digestible energy consumed

$REG = 1.164 – (5.160 \times 10^{-3} \times DE\%) + (1.308 \times 10^{-5} \times DE\%^2) – (37.4/DE\%)$

DE% = digestible energy expressed as a percentage of gross energy

Activity Data of Enteric Fermentation (3A1)

The activity data for assessing GHG emissions in this category is the livestock population. A Tier 1 assessment requires population data by species, while a Tier 2 assessment necessitates more detailed categorization by species, gender, and age. The activity data were obtained from the annual report of the Department of Livestock Development. (Tables 2-102 and 2-103)

Table 2-102: Thailand's livestock populations for 2020-2022 (dairy cattle, beef cattle and buffalo)

Livestock				Populations (heads)		
				2020	2021	2022
Dairy cattle	Male			36,686	47,484	53,445
	Female	Heifers (<1 year)		127,498	149,739	150,229
		Heifers (1 year to 1st pregnancy)		151,228	176,059	166,667
		Milking cows (lactating cows)		320,613	358,247	365,792
		Milking cows (dry cows)		71,211	78,989	76,102
	Sum			707,236	810,518	812,235
Beef cattle	Native	Male		1,124,130	1,270,250	1,444,928
		Female	Heifers	1,316,853	1,620,882	1,927,528
			From 1st pregnancy	1,062,013	1,275,340	1,528,255
	Pure/crossed breed	Male		653,296	786,883	1,031,405
		Female	Heifers	946,311	1,174,206	1,536,385
			From 1st pregnancy	929,868	1,184,236	1,630,371
	Fattening			197,669	270,609	295,239
	Sum			6,230,140	7,582,406	9,394,111
Buffalo	Male			355,606	431,284	490,111
	Female	Young		502,309	615,489	692,514
		From 1st pregnancy		398,159	474,241	558,516
	Sum			1,256,074	1,521,014	1,741,141

Table 2-103: Thailand's livestock populations for 2020-2022 (all other livestock)

Livestock			Population (heads) 2020	2021	2022
Swine	Native		531,264	561,512	346,893
	Breed	Sire	83,248	83,770	55,135
		Sow	1,059,957	1,102,185	1,058,045
		Male piglets	87,381	133,692	80,492
		Female piglets	98,293	108,836	99,598
	Fattening	Fattening	8,099,660	8,945,080	7,169,508
		Piglets	2,268,452	2,168,812	1,949,523
	Sum		12,228,255	13,103,887	10,759,194
Goat			962,884	1,277,148	1,505,381
Sheep			83,222	112,903	128,314
Chicken	Native		94,130,344	111,855,130	117,367,900
	Broiler		287,209,517	301,936,950	300,362,008
	Crossed breed		970,437	1,409,911	1,520,154
	Layer		57,371,645	58,291,524	66,986,334
	Broiler breeders		11,380,502	11,160,433	11,525,405
	Layer breeders		1,035,098	1,040,941	1,101,010
	Sum		452,097,543	485,694,889	498,862,811
Duck			31,457,867	32,947,181	33,604,921

Emission Factors of Enteric Fermentation (3A1)

The supporting data for estimating Tier 2 emission factor for dairy cattle, beef cattle and buffalo are animal and feed characteristics. These data were obtained from literature reviews (>15 national journal articles and handbooks), and expert judgement, mainly from the Department of Livestock Development, and IPCC defaults. Tier 1 emission factors of CH_4 for developing countries and/or warm climate were adopted for enteric fermentation for poultry, sheep and goats, while the Tier 1 emission factor for swine was applied from developed countries. (Table 2-104)

Table 2-104: Emission factors for CH_4 emissions (enteric fermentation) for 2020-2022

Livestock				EF (kg CH_4/head/year)
Dairy cattle	Male			18.89
	Female	Heifers	<1 year	29.21
			1 year to 1st pregnancy	43.52
		Milking cows	Lactating cows	92.86
			Dry cows	45.62
Beef cattle	Native	Male		44.63
		Female	<1 year	20.79
			Heifer >1 year	46.76
			From 1st pregnancy	47.18
	Pure/crossed breed	Male		64.96
		Female	<1 year	31.81
			Heifer >1 year	69.83
			From 1st pregnancy	62.02
	Fattening			55.72
Buffalo		Male		68.38
		Female	Young	52.25
			From 1st pregnancy	83.81
Swine				1.5
Goat and sheep				5
Poultry				-

Uncertainties

Since the country-specific and default values in the 2006 IPCC Guidelines were adopted for the emission factors of Enteric Fermentation, the uncertainties indicated in the 2006 IPCC Guidelines (-50% to +50% for CH_4) were adopted. Since the values in the annual report of the Department of Livestock Development were used for the activity data, the default values in the 2006 IPCC Guidelines (-20% to +20%) were adopted for the uncertainty of activity data. Therefore, the uncertainty of the emissions from Enteric Fermentation was estimated as -53.85% to +53.85% for CH_4.

Time-series Consistency

The activity data of Enteric Fermentation given in the annual report of the Department of Livestock Development are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials.

In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

Emissions estimated for Enteric Fermentation (3A1) follow Tier 2 and Tier 1 approaches. Capacity building and support are needed to update and revise animal characteristics for the Tier 2 approach (if appropriate).

Estimated Emissions from Enteric Fermentation (3A1)

The assessment of GHG emissions from enteric fermentation in livestock for the years 2020–2022 indicates that the majority of emissions are produced by ruminants, with beef cattle being the largest contributor. The summary of GHG emissions by animal type is presented in Table 2-105.

Table 2-105: GHG emissions from enteric fermentation for 2020–2022

Year	Enteric CH_4 emissions ($ktCO_2eq$)							
	Dairy cattle	Beef cattle	Buffalo	Swin	Goat	Sheep	Poultry	Sum
2020	1,232.58	8,511.30	2,350.17	513.59	134.80	11.65	-	12,754.08
2021	1,394.53	10,386.05	2,839.20	550.36	178.80	15.81	-	15,364.76
2022	1,402.57	13,001.76	3,262.30	451.87	210.75	17.96	-	18,347.24

CH_4 emissions from enteric fermentation in livestock between 2000 and 2022 have shown considerable fluctuations in relation to livestock populations. Emissions increased from 2000 to 2009, followed by a sharp decline from 2010 to 2014. However, from 2015 to 2022, there was a notable upward trend, culminating in a significant rise in 2021-2022. In Thailand, beef cattle are one of the key sources of GHG emissions. The beef cattle population decreased from 2009 to 2014 but began to rise again, experiencing a sharp increase between 2020 and 2022. Hence, since 2014, the increasing population of livestock—especially beef cattle—has driven the upward trend in CH_4 emissions (Figure 2-59).

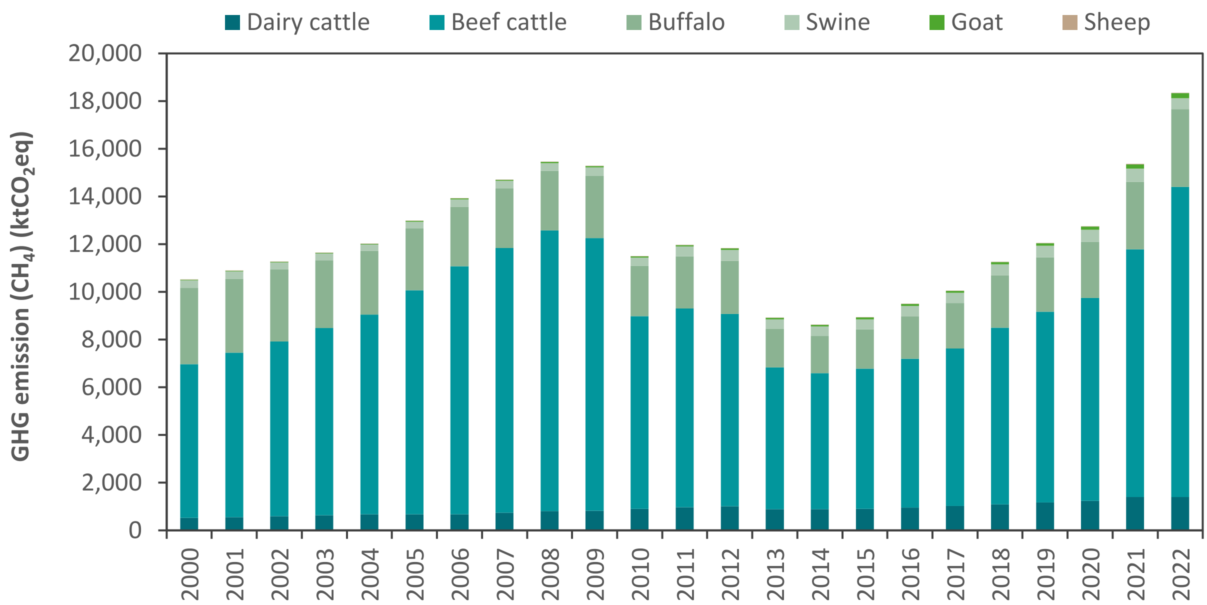
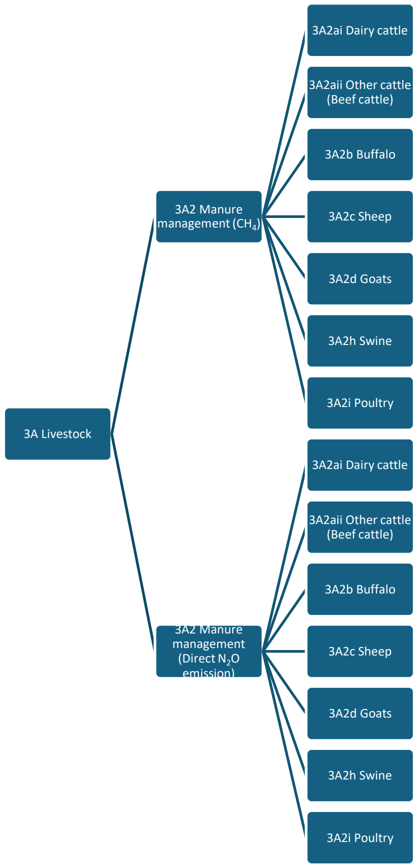


Figure 2-59: GHG emissions from enteric fermentation for 2000-2022

Manure Management (3A2)

Category Description

Animal manure primarily consists of organic matter, water, and various nutrients. The management of manure can take several forms, each affecting greenhouse gas emissions differently. Manure management is responsible for the release of two main GHGs: CH_4 and N_2O.



Estimation Method

CH_4

Given the availability of activity data and other supporting information, a Tier 2 assessment was applicable for key livestock groups with high CH_4 emissions, including dairy cattle, beef cattle, buffalo, and swine. Population data were collected and categorized by species, gender, and age. For other species, such as poultry, sheep, and goats, a Tier 1 assessment was utilized.

$$CH_{4\ Manure} = \sum_{(T)} (EF_{(T)} \times N_{(T)} \times 10^{-6}) \qquad (3B\text{-}1)$$

Where:

$CH_{4\ Manure}$ = CH_4 emissions from manure management for a defined population (Gg CH_4/year)
$EF_{(T)}$ = emission factor for the defined livestock population (kg CH_4/head/year)
$N_{(T)}$ = the number of head of livestock species/category T in the country (head)

(3B-2)

$$EF_{(T)} = (VS_{(T)} \times 365) \times [B_{o(T)} \times 0.67 \times \sum \frac{MCF_{(S,k)}}{100} \times MS_{(T,S,k)}]$$

Where:

$EF_{(T)}$ = annual CH_4 emission factor for livestock category T (kg CH_4/year)

$VS_{(T)}$ = daily volatile solid excreted for livestock category T (kg dry matter/head/day)

$$VS = [GE \times (1 - \frac{DE\%}{100}) + (UE \times GE)] \times (\frac{1 - ASH}{18.45})$$

VS = volatile solid excretion per day on a dry-organic matter basis (kg VS/day)

GE = gross energy intake, MJ day-1

DE% = digestibility of the feed in percent (%)

(UE • GE) = urinary energy expressed as fraction of GE

Typically, 0.04GE can be considered urinary energy excretion by most ruminants (reduce to 0.02 for ruminants fed with 85% or more grain in the diet or for swine).

ASH = the ash content of manure calculated as a fraction of the dry matter feed intake (0.08 for cattle)

18.45 = conversion factor for dietary GE per kg of dry matter (MJ/kg)

$B_{o(T)}$ = maximum methane producing capacity for manure produced by livestock category T (m^3 CH_4/kg VS)

0.67 = conversion factor of m^3 CH_4 to kg CH_4 (kg/m^3)

$MCF_{(S,k)}$ = methane conversion factors for each manure management system S by climate region k (%)

$MS_{(T,S,k)}$ = fraction of livestock category T's manure handled using manure management system S in climate region k (%)

N_2O

A Tier 2 assessment is also appropriate for N_2O emissions, as country-specific values are used for the nitrogen excreted by animals according to various manure management systems (MS).

$$N_2O_{D(mm)} = \left[\sum_S\left[\sum_T\left(N_{(T)} \times Nex_{(T)} \times MS_{(T,S)}\right)\right] \times EF_{3(S)}\right] \times \frac{44}{28} \qquad (3B\text{-}3)$$

$$Nex_{(T)} = N_{rate(T)} \times \frac{TAM}{1000} \times 365 \qquad (3B\text{-}4)$$

Where:

$N_2O_{D(mm)}$ = direct N_2O emissions from manure management in the country (kg N_2O/year)

$N_{(T)}$ = number of head of livestock species/category T in the country (head)

$Nex_{(T)}$ = annual average N excretion per head of species/category T in the country (kg N/head/year)

$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country

$EF_{3(S)}$ = emission factor for direct N_2O emissions from manure management system S in the country (kg N_2O-N/kg N) in manure management system S

S = manure management system

T = species/category of livestock

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

$N_{rate(T)}$ = default N excretion rate (kg N/1000 kg animal mass/day)

TAM = typical animal mass for livestock category T (kg/head)

365 = time conversion (days/year)

Activity data of Manure Management (3A2)

The primary activity data for assessing GHG emissions in this category is livestock population (N_T), which is the same data used in section 3A enteric fermentation. Additionally, the assessment of GHG emissions from manure management utilizes the following supporting activity data:

1. **Nitrogen excretion rate for each species ($N_{ex(T)}$)**: This supporting data is crucial for calculating N_2O emissions. In this assessment, $N_{ex(T)}$ was calculated using equations from the 2006 IPCC GLs, which requires the recommended nitrogen excretion rate for livestock ($N_{rate(T)}$) and the animal body weight (TAM). The calculated nitrogen excretion rates per animal ($N_{ex(T)}$) are presented below. (Table 2-106)
2. **Proportion of manure or nitrogen excreted by animals according to different manure management systems (MS)**: This supporting data is used for both CH_4 and N_2O emissions. In this assessment, country-specific values were applied based on evaluations from experts and practitioners with relevant experience. The data includes information on specific manure management systems, particularly for swine and layer chickens used for biogas production. The results are shown below. (Table 2-107)

Table 2-106: IPCC defaults for N_{rate}, TAM and N_{ex}

Livestock				$N_{ex(T)}$ (kg N/head/year)
Dairy cattle	Male			12.77
	Female	Heifers	<1 year	23.94
			1 year to 1st	50.82
		Milking cows	Lactating cows	77.35
			Dry cows	77.35
Beef cattle	Native	Male		22.65
		Female	<1 year	9.76
			1 year to heifers	22.39
			From 1st pregnancy	32.54
	Pure/crossed breed	Male		34.70
		Female	<1 year	15.48
			1 year to heifers	34.09
			From 1st pregnancy	48.33
	Fattening			40.35
Buffalo		Male		37.52
		Female	Young	25.75
			From 1st pregnancy	61.99
Swine	Native			4.82
	Breed	Sire and sow		14.89
		Male piglets		1.84
		Female piglets		1.84
	Fattening	Fattening		9.20
		Piglets		1.84
Goat				15.00
Sheep				11.96
Chicken	Native and crossed breed			0.54
	Broiler			0.36
	Layer			0.54
	Broiler breeders			0.54
	Layer breeders			0.54
Duck				0.82

Table 2-107: %MS categories by manure management systems

Livestock	%MS											
	Pasture /range/ paddock	Daily spread	Solid storage	Dry lot	Poultry litter		Uncovered anaerobic lagoon	Anaerobic digestion	Deep bedding	Composting-intensive windrow	Others	Sum
					With bedding	Without bedding						
Dairy cattle	5	51	23	14			7					**100**
Beef cattle	49		51									**100**
Buffalo	50		25	25								**100**
Swine (native)	17.5		80						2.5			**100**
Swine (breed and fattening)		19	10				7	64				**100**
Goat and sheep	18		82									**100**
Chicken (native and crossed)	80		20									**100**
Chicken (broiler)					100							**100**
Chicken (layer)					30	48		12		1	9	**100**
Chicken (broiler breed)					100							**100**
Chicken (layer breed)					100							**100**
Duck	45				41	14						**100**

Emission Factors of Manure Management (3A2)

The emission factors used are the annual CH_4 emissions per head. For the Tier 1 assessment, recommended values from the 2006 IPCC GLs were applied, while the Tier 2 assessment utilized country-specific emission factors. This required the collection of necessary domestic data to calculate emissions according to the equations in 2006 IPCC GLs, such as the total energy intake of the animals, the energy used for digestion, the conversion rate of manure to CH_4, and the proportion of manure based on different manure management systems.

In this assessment, country-specific emission factors (Tier 2) were used for dairy cattle, beef cattle, buffalo, and swine, while recommended values (Tier 1) were applied for goats, sheep, and poultry. The emission factors used are presented below. (Table 2-108)

Table 2-108: Manure CH_4 emission factors

Livestock				Manure CH_4 (kg CH_4/head/year)
Dairy cattle	Male			4.39
	Female	Heifers	<1 year	6.79
			1 year to 1st pregnancy	10.11
		Milking cows	Lactating cows	21.57
			Dry cows	10.60
Beef cattle	Native	Male		5.12
		Female	<1 year	2.32
			1 year to heifers	5.37
			From 1st pregnancy	5.42
	Pure/crossed breed	Male		7.46
		Female	<1 year	3.55
			1 year to heifers	8.01
			From 1st pregnancy	7.12
	Fattening			6.22
Buffalo		Male		2.64
		Female	Young	2.01
			From 1st pregnancy	3.23
Swine		Native		1.13
		Breed	Sire and sow	2.38
			Male piglets	4.81
			Female piglets	0.56
		Fattening	Fattening	2.82
			Piglets	0.56
Goat				0.22
Sheep				0.20
Poultry				0.02

The emission factor used is the N_2O emissions from manure in various manure management systems (EF_3). For the Tier 1 assessment, recommended values from the 2006 IPCC GLs were applied. In the Tier 2 assessment, either recommended values or country-specific values may be used (as specified in the Tier 2 calculation section). However, a review of domestic data revealed no reported emission factors, so this assessment relies on the recommended values from the 2006 IPCC GLs. The emission factors used are presented below. (Table 2-109)

Table 2-109: Manure N_2O emission factors

MS		EF_3 (kg N_2O-N/kg N excreted)
Pasture/range/paddock		0.02
Daily spread		0
Solid storage		0.005
Dry lot		0.02
Poultry litter	With bedding	0.001
	Without bedding	0.001
Uncovered anaerobic lagoon		0
Anaerobic digestion		0
Deep bedding		0.01
Composting-intensive windrow		0.1
Others		0

Uncertainties

Since the country-specific and default values in the 2006 IPCC Guidelines were adopted for the emission factors of Manure Management, the uncertainties indicated in the 2006 IPCC Guidelines (-30% to +30% for CH_4 and -111.80% to +111.80% for N_2O) were adopted. Since the values in the annual report of the Department of Livestock Development were used for the activity data, the default values in the 2006 IPCC Guidelines (-20% to +20% for CH_4 and -53.85% to +53.85% for N_2O) were adopted for the uncertainty of activity data. Therefore, the uncertainty of the emissions from Manure Management was estimated as -36.06% to +36.06% for CH_4 and -124.09% to +124.09% for N_2O.

Time-series Consistency

The activity data of Manure Management given in the annual report of the Department of Livestock Development are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

Emissions estimated for Manure Management (3A2) follow Tier 2 and Tier 1 approaches. Capacity building and supports are needed to update and revise animal and manure characteristics for Tier 2 approach (if appropriate). The percentage of manure management (MS) for certain livestock, particularly swine, also needs to be updated.

Estimated Emissions from Manure Management (3A2)

The assessment of GHG emissions from manure management for the years 2020–2022 indicates that CH_4 emissions were higher than N_2O emissions. The animals contributing the most to GHG emissions for both types of gases are beef cattle and swine. A summary of GHG emissions by animal type is presented below (Table 2-110).

Table 2-110: GHG emissions from manure management for 2020-2022

Livestock	GHG emissions (ktCO_2eq)								
	2020			2021			2022		
	CH_4	N_2O	Sum	CH_4	N_2O	Sum	CH_4	N_2O	Sum
Dairy cattle	286.32	68.29	354.61	323.94	77.25	401.19	325.80	77.20	403.00
Beef cattle	973.47	191.39	1,164.86	1,187.71	234.56	1,422.27	1,487.05	295.23	1,782.28
Buffalo	90.58	132.62	223.20	109.43	159.87	269.30	125.74	184.37	310.11
Swine	843.07	24.53	867.60	915.80	26.53	942.33	756.56	20.96	777.52
Goat	5.93	24.66	30.59	7.87	32.71	40.58	9.27	38.56	47.83
Sheep	0.47	1.70	2.17	0.63	2.30	2.93	0.72	2.62	3.34
Poultry	270.79	96.14	366.93	290.44	103.03	393.47	298.18	107.75	405.93
Sum	**2,470.63**	**539.33**	**3,009.97**	**2,835.82**	**636.26**	**3,472.08**	**3,003.33**	**726.69**	**3,730.02**

GHG emissions from manure management from 2000 to 2022 mirrored the trends observed in CH_4 emissions from enteric fermentation. Emissions rose steadily from 2000 to 2009, followed by a sharp decline from 2010 to 2014. However, from 2015 to 2022, there was a significant upward trend, culminating in a peak in 2021-2022. These emissions exhibited considerable fluctuations related to livestock populations, primarily driven by changes in the beef cattle and swine population. Since 2014, the increasing livestock population—especially beef cattle and swine—has played a key role in the upward trend of GHG emissions (Figure 2-60).

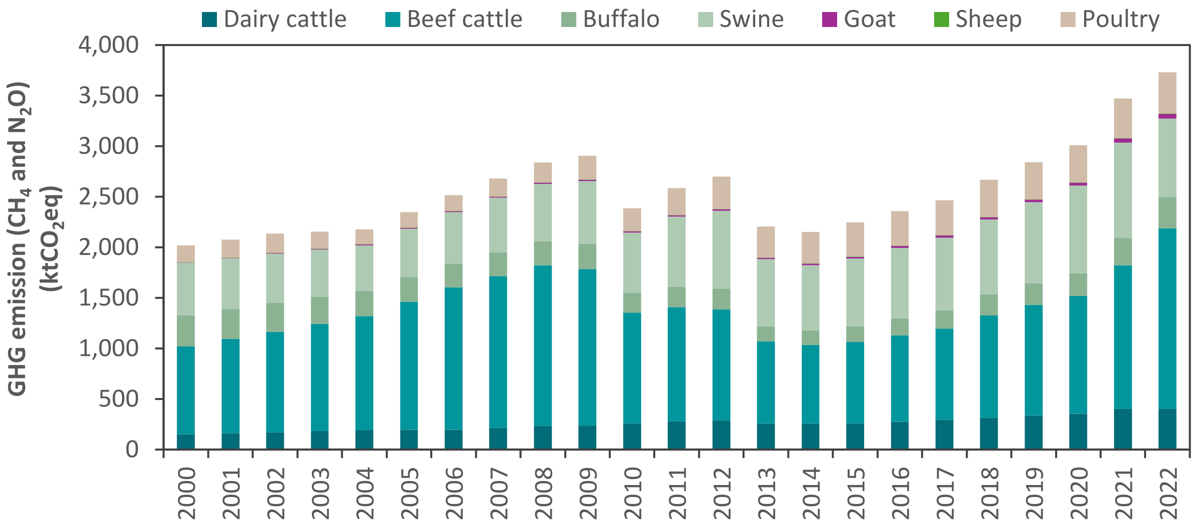
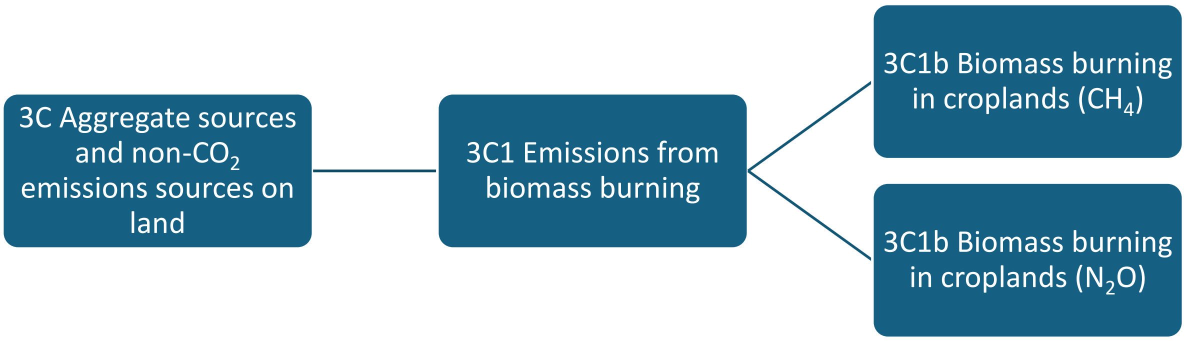


Figure 2-60: GHG emissions from manure management for 2000-2022

Biomass Burning in Croplands (3C1b)

Category Description

Biomass burning in croplands generates significant GHGs, primarily CH_4 and N_2O. This biomass burning often occurs with insufficient oxygen, which can lead to the production of other gases, such as carbon monoxide (CO) and nitrogen oxides (NO_x). For biomass burning in croplands in the 2006 IPCC GLs, CO_2 emissions do not need to be estimated and reported.



Estimation Method

$$L_{fire} = A \times M_B \times C_f \times G_{ef} \times 10^{-3} \qquad (3C1b)$$

Where:

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG (tonnes)

A = area burnt (ha)

M_B = mass of fuel available for combustion (tonnes/ha)

C_f = combustion factor

G_{ef} = emission factor (g/kg dry matter burnt)

Activity data for Biomass Burning in Croplands (3C1b)

In this inventory, GHG emissions from biomass burning in croplands were investigated for major rice, second rice, sugarcane, maize and cassava. The assessment of GHG emissions in the agriculture sector relies primarily on two key data points: the area of agricultural land burnt (A) and the mass of fuel available for combustion (M_B). Given the current availability of activity data and supporting information, a Tier 1 assessment was feasible.

At present, Thailand lacks comprehensive national-level data on direct agricultural burnt areas. As a result, estimates are based on information regarding the burning of agricultural residues. The methodology for assessing the proportion of agricultural residues burnt was adapted from the 1996 IPCC GLs and is widely implemented.

To calculate the burnt area, relevant data includes both the harvested area and the proportion of agricultural residues burnt. For calculating A x M_B, data on crop production, dry weight of crop production, and various proportions of agricultural residues are used. Key agencies providing data on harvested areas and production quantities include the Office of Agricultural Economics and the Office of the Cane and Sugar Board. The proportions of agricultural residues were compiled from research studies and expert evaluations (Table 2-112).

This comprehensive dataset allows for the effective assessment of both A x M_B. Furthermore, in evaluating GHG emissions from biomass burning in croplands, supporting activity data is utilized, specifically the burning coefficient (C_f). This coefficient is recommended at 0.80 according to the 2006 IPCC GLs, reflecting the limitations of available domestic data. (Table 2-112)

Table 2-111: Harvested area of croplands and crop production of major economic crops for 2020-2022

Crop	2020		2021		2022	
	Harvested area (ha)	Crop production (tonnes)	Harvested area (ha)	Crop production (tonnes)	Harvested area (ha)	Crop production (tonnes)
Major rice	9,615,006	26,423,822	9,641,807	26,806,578	9,518,692	26,711,735
Second rice	1,155,289	4,553,778	1,329,143	5,310,446	1,522,848	6,171,197
Sugarcane	1,485,321	66,843,432	1,763,576	105,944,353	1,823,812	113,024,061
Maize	1,121,462	4,995,169	1,065,748	4,847,845	1,005,729	4,700,344
Cassava	1,426,920	28,999,122	1,665,010	35,094,485	1,587,369	34,068,005

Table 2-112: Fractions for agricultural residues for biomass burning in croplands

Crop	Fraction (dry)	Residue-to-crop ratio	Fraction (burnt)	Fraction (removal)	Fraction (left)
Major rice	0.85	1.54	0.29	0.28	0.43
Second rice	0.85	1.54	0.57	0.00	0.43
Sugarcane	0.25	0.47	0.47	0.003	0.527
Maize	0.855	1.05	0.34	0.00	0.66
Cassava	0.22	0.46	0.00	0.28	0.72

Emission Factors for Biomass Burning in Croplands (3C1b)

The emission factors utilized in this assessment pertain to GHGs and non-GHGs released during the field burning of agricultural residues (Table 2-113). These factors are expressed in g/kg dry weight and include the gases CH_4, N_2O, CO, and NO_x. For Tier 1 assessments, default G_{ef} from the 2006 IPCC GLs were adopted.

Table 2-113: Emission factors (G_{ef}) for biomass burning in croplands

G_{ef} (g/kg dry matter burnt)			
N_2O	CH_4	CO	NO_x
0.07	2.7	92	2.5

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of Biomass Burning in Croplands, the uncertainties indicated in the 2006 IPCC Guidelines (-100% to +100% for CH_4 and N_2O) were adopted. Since the values in the annual report of the Office of Agricultural Economics and the Office of the Cane and Sugar Board were used for the activity data, there is not default values in the 2006 IPCC Guidelines available (0%) are adopted for the uncertainty of activity data. Therefore, the uncertainty of the emissions from Biomass Burning in Croplands was estimated as -100% to +100% for CH_4 and N_2O.

Time-series Consistency

The activity data of Biomass Burning in Croplands given in the annual report of the Office of Agricultural Economics and the Office of the Cane and Sugar Board are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

Emissions estimated for Biomass Burning in Croplands (3C1b) follow Tier 1 approaches. Capacity building and support are needed to develop a technique and reporting system for agricultural areas affected by burning, using direct measurement data such as satellite imagery to quantify cropland areas, including estimates of biomass fuel mass (MB), where technically feasible.

Estimated Emissions from Biomass Burning in Croplands (3C1b)

The assessment of GHG and non-GHG emissions from biomass burning in croplands for 2020–2022 showed that major rice was the highest contributors to all gases, followed by sugarcane, second rice and maize. (Tables 2-114 and 2-115) This is primarily due to the fact that the largest cultivated area is dedicated to major rice, followed by sugarcane, second rice, and maize. Since the fraction (burnt) of cassava is zero, GHG emissions were not estimated.

Table 2-114: GHG emissions from biomass burning in croplands for 2020-2022

Crop	GHG emissions ($ktCO_2eq$)								
	2020			2021			2022		
	CH_4	N_2O	Sum	CH_4	N_2O	Sum	CH_4	N_2O	Sum
Major rice	606.66	148.86	755.52	615.45	151.01	766.46	613.27	150.48	763.75
Second rice	205.49	50.42	255.92	239.64	58.8	298.44	278.48	68.33	346.81
Sugarcane	223.26	54.78	278.04	353.85	86.83	440.68	377.5	92.63	470.13
Maize	92.21	22.63	114.84	89.49	21.96	111.45	86.77	21.29	108.06
Sum	**1,127.62**	**276.69**	**1,404.31**	**1,298.44**	**318.6**	**1,617.03**	**1,356.02**	**332.73**	**1,688.75**

Table 2-115: Non-GHG emissions from biomass burning in croplands for 2020-2022

Crop	Non-GHG emissions (Gg)					
	2020		2021		2022	
	CO	NO_x	CO	NO_x	CO	NO_x
Major rice	738.26	20.06	748.96	20.35	746.35	20.28
Second rice	250.07	6.8	291.62	7.93	338.89	9.21
Sugarcane	271.69	7.38	430.62	11.7	459.39	12.48
Maize	112.22	3.05	108.91	2.96	105.56	2.87
Sum	**1,372.24**	**37.29**	**1,580.11**	**42.94**	**1,650.19**	**44.84**

GHG emissions from biomass burning in croplands between 2000 and 2022 have shown significant variability, primarily influenced by the size of the harvested area. This is particularly evident with second rice, where cultivated and harvested areas can fluctuate dramatically from year to year, likely due to variations in climate, environmental factors, related policies, and crop prices. The trends in GHG emissions for this sector are illustrated below (Figure 2-61).

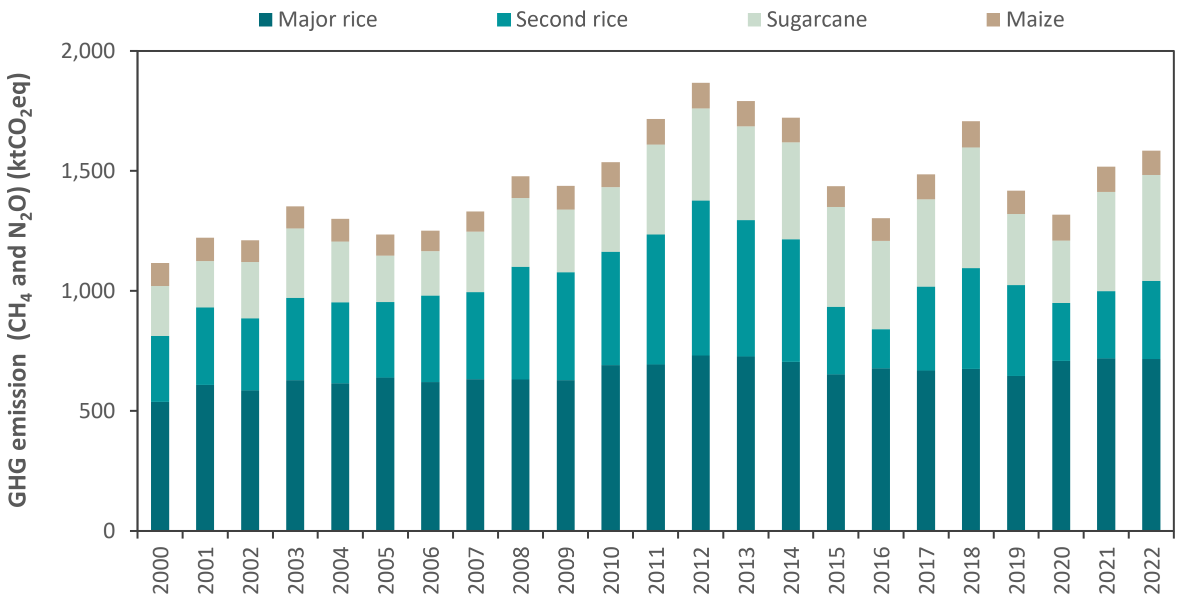
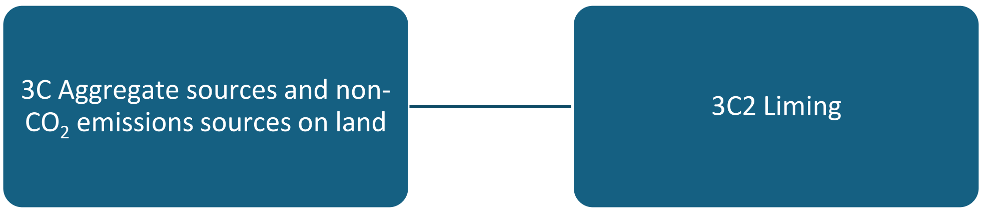


Figure 2-61: GHG emissions from biomass burning in croplands during 2000-2022

Liming (3C2)

Category Description

Adding carbonates to soils in the form of lime (e.g., $CaCO_3$) or dolomite ($CaMg(CO_3)_2$) leads to CO_2 emissions as the carbonate limes dissolve and release bicarbonate ($2HCO_3^-$), which evolves into CO_2 and water (H_2O). In Thailand, CO_2 emission from liming is estimated by using the Tier 1 approach, due to insufficient data for specific national estimates. Moreover, lime application shares a relatively small portion of GHG emissions in the agriculture sector.



Estimation Method

$$CO_2\text{-C Emission} = (M_{Limestone} \times EF_{Limestone}) + (M_{Dolomite} \times EF_{Dolomite}) \qquad (3C2)$$

Where:

CO_2-C Emission	=	annual C emissions from lime application (tonnes C/year)
M	=	annual amount of calcic limestone or dolomite (tonnes/year)
EF	=	emission factor (tonne of C/tonne of limestone or dolomite)
CO_2 Emission	=	CO_2-C Emission × 44/12 (tonnes CO_2/year)

Activity Data for Liming (3C2)

The data used to assess GHG emissions in this subcategory includes the amounts of lime applied in the form of limestone ($M_{Limestone}$) and dolomite ($M_{Dolomite}$) on agricultural lands. This information was provided by the Land Development Department, which distributes lime to farmers for soil improvement, as illustrated below (Table 2-116).

Table 2-116: Lime application in croplands for 2020-2022

Lime	Quantity (tonnes)		
	2020	2021	2022
Limestone	2,227	2,288	1,400
Marl [a]	12,500	11,500	11,500
Dolomite	27,000	26,920	27,000

Remark: [a] Marl is assumed to contain 50% $CaCO_3$.

Emission Factors for Liming (3C2)

The emission factors for assessing GHG emissions in this subcategory were derived from Tier 1 assessments, utilizing the IPCC default values for CO_2 EFs: 0.12 for limestone and 0.13 for dolomite.

Uncertainties

Since the values in the annual report of the Land Development Department were used for the activity data, default values in the 2006 IPCC Guidelines were not available. Therefore, the uncertainty of the emissions from liming was estimated as -50% to +50% for CO_2.

Time-series Consistency

The activity data of liming given in the annual report of the Land Development Department are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

Emissions estimated for Liming (3C2) follow Tier 1 approaches. Capacity building and support are needed to develop a technique and reporting system for lime materials used in Thailand (If appropriate).

Estimated Emissions from Liming (3C2)

The assessment of CO_2 emissions from lime application in croplands for the years 2020–2021 is primarily based on dolomite. This is due to the fact that most of the lime supplied to farmers by the Land Development Department is in dolomitic form rather than limestone, resulting in a higher proportion of CO_2 emissions compared to limestone (Table 2-117).

Table 2-117: GHG emissions from lime application for 2020-2022

Year	CO_2 emissions ($ktCO_2$)		
	Limestone	Dolomite	Sum
2020	3.73	12.87	16.60
2021	3.54	12.83	16.37
2022	3.15	12.87	16.02

With activity data available since 2011, CO_2 emissions in this subcategory can be assessed from that year onward. It has been noted that CO_2 emissions have shown a consistent downward trend, as illustrated below (Figure 2-62).

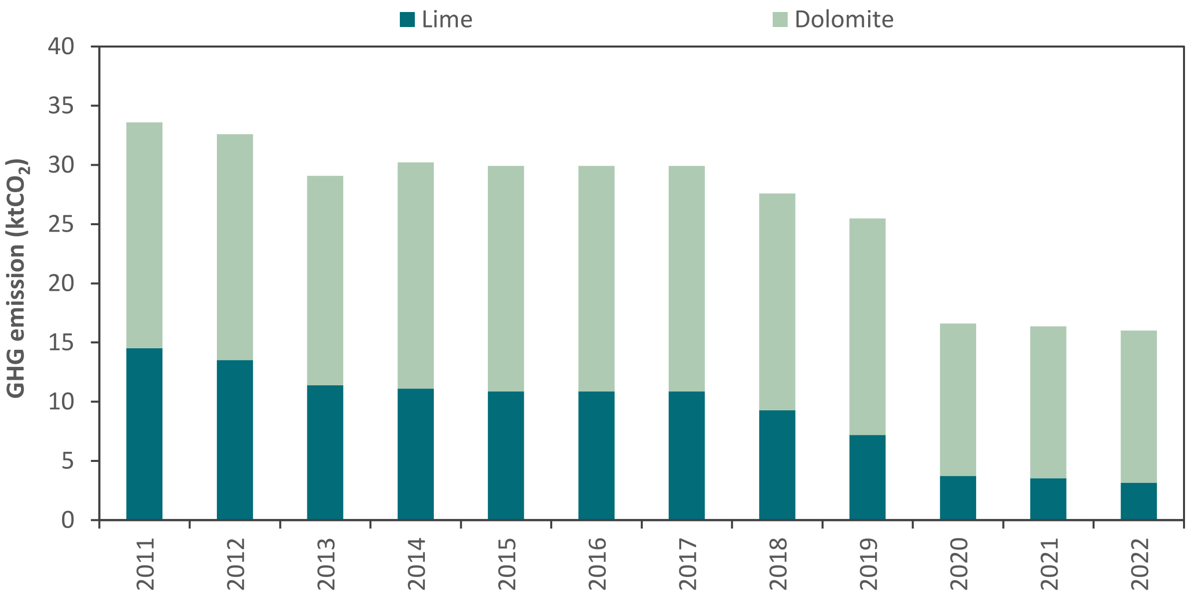
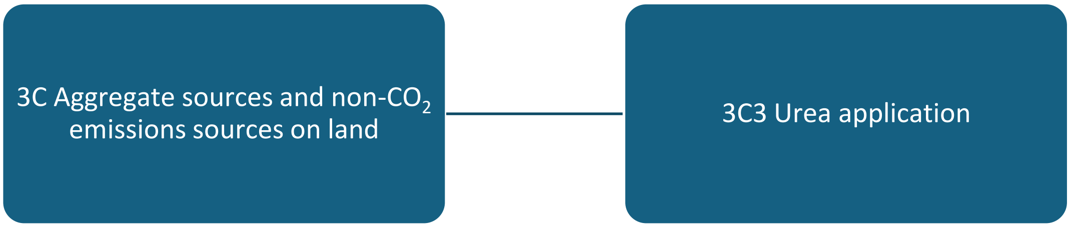


Figure 2-62: GHG emissions from lime applications for 2011-2022

Urea Fertilization (3C3)

Category Description

Adding urea to soils during fertilization leads to a loss of CO_2 that was fixed in the industrial production process. This source category is included because the CO_2 removal from the atmosphere during urea manufacturing is estimated in the Industrial Processes and Product Use Sector (IPPU Sector). In Thailand, CO_2 emission from urea fertilization is estimated by using the Tier 1 approach.



Estimation Method

$$CO_2\text{-C Emission} = M \times EF \qquad (3C3)$$

Where:

CO_2-C Emission = annual C emissions from urea application (tonnes C/year)
M = annual amount of urea fertilization (tonnes/year)
EF = emission factor (tonne of C/tonne of urea)
CO_2 Emission = CO_2-C Emission × 44/12 (tonnes CO_2/year)

Activity Data for Urea Fertilization (3C3)

The activity data for assessing CO_2 emissions in this subcategory pertains to the quantity of urea fertilizer applied in agricultural areas (M). This information is sourced from the Department of Agriculture, which tracks the amount of imported and exported chemical fertilizers (urea). The amount of urea used in this assessment was calculated by subtracting the exported urea from the imported urea (Table 2-118).

Table 2-118: Urea applications in croplands for 2020-2022

Year	Imported urea (tonnes)	Exported urea (tonnes)
2020	2,113,903	156,837
2021	1,967,029	202,234
2022	1,514,854	83,239

Emission Factors for Urea Fertilization (3C3)

The emission factors for assessing GHG emissions in this subcategory were derived from Tier 1 assessments, utilizing the IPCC default values for CO_2 EFs (0.20).

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of Urea Fertilization, the uncertainties indicated in the 2006 IPCC Guidelines (-50% to +50% for CO_2) were adopted. Since the values in the annual report of the Department of Agriculture were used for the activity data, default values in the 2006 IPCC Guidelines were not available. Therefore, the uncertainty of the emissions from Urea Fertilization was estimated as -50% to +50% for CO_2.

Time-series Consistency

The activity data of Urea Fertilization given in the annual report of the Department of Agriculture are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

Emissions estimated for Urea Fertilization (3C3) follow Tier 1 approaches. Capacity building and support are needed to develop a Tier 2 approach for urea fertilization (if appropriate).

Estimated Emissions from Urea Fertilization (3C3)

The assessment of CO_2 emissions from urea fertilization in croplands for 2020–2022 is shown in Table 2-119. The variability in fertilizer usage, including urea, is influenced by several factors, particularly fertilizer prices and agricultural product prices. In 2021-2022, rising fertilizer costs caused farmers to reduce their application rates, which is evident in the decline of imported synthetic fertilizers.

Table 2-119: GHG emissions from urea fertilization for 2020-2022

Year	Urea application (tonnes)	GHG emissions ($ktCO_2$)
2020	2,113,903	1,435.18
2021	1,764,795	1,294.18
2022	1,431,615	1,049.85

CO_2 emissions from urea fertilizer application between 2000 and 2017 showed a consistent upward trend, corresponding to the rising use of synthetic fertilizers, including urea (Figure 2-63). However, starting in 2018, CO_2 emissions began to decline. The variability in urea usage in agricultural areas was influenced by several factors, with the main determinants being the expansion of cultivated land, fertilizer prices, and agricultural product prices.

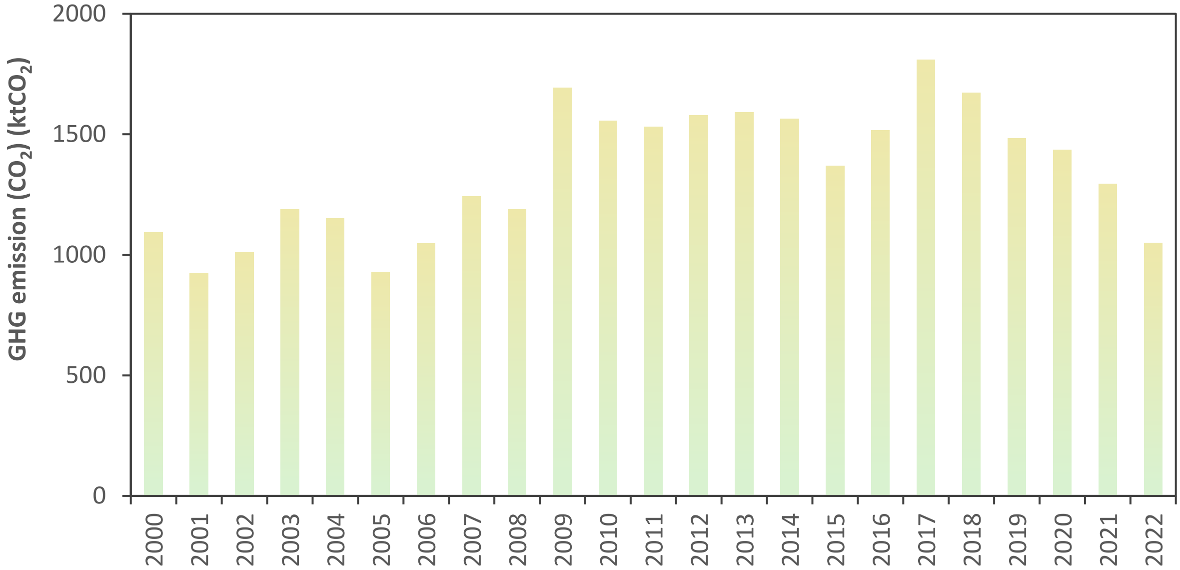
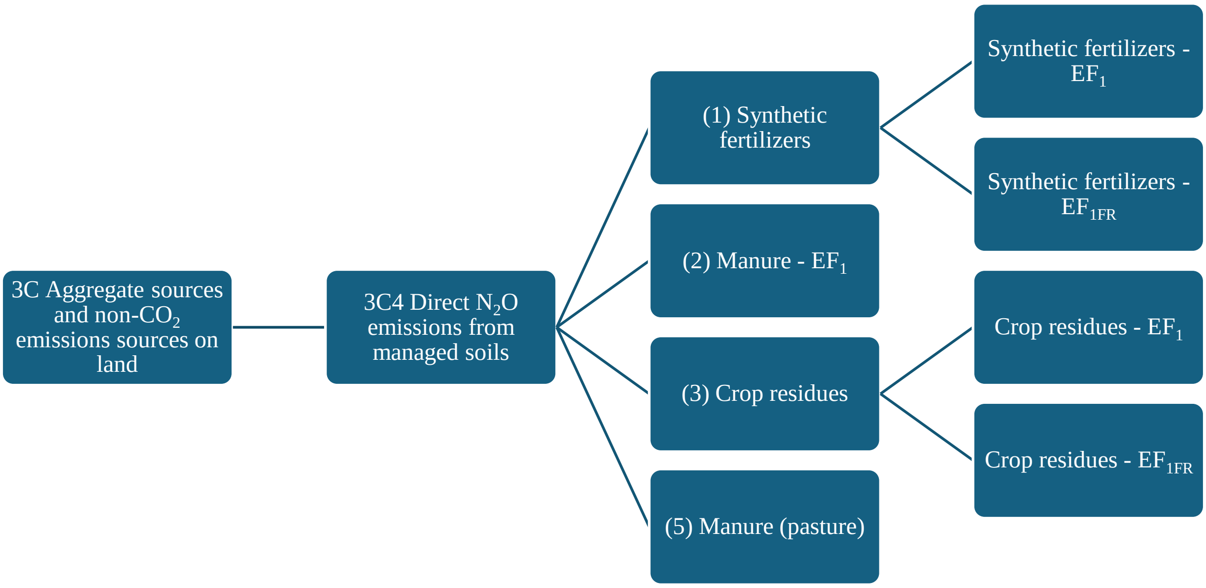


Figure 2-63: GHG emissions from urea applications for 2000-2022

Direct N_2O emissions from managed soils (3C4)

Category Description

N applied to the soil provides N substrate for microorganisms and is transformed by microbial activity, in particular, through nitrification and denitrification processes. During these processes, N_2O is produced and emitted. Sources of N applied are from human-induced N additions or changes of land-use and/or management practices that mineralize soil organic N. In the methodology for estimating direct N_2O emissions from managed soils, N sources include synthetic N fertilizers, organic N applied as fertilizer, urine and dung N deposited on pasture, range and paddock by grazing animals, N in crop residues (above-ground and below-ground), including from N-fixing crops and from forages during pasture renewal, N mineralisation associated with loss of soil organic matter resulting from change of land use or management of mineral soils, and drainage/management of organic soils (i.e., Histosols). In Thailand, N sources used to estimate direct N_2O emissions from soils are synthetic fertilizer, animal manure, urine and dung deposited, and crop residues. In addition, the Tier 1 methodology was applied to estimate direct N_2O emissions from soil of these N sources.



Estimation Method

$$N_2O_{Direct}\text{-}N = N_2O\text{-}N_{N\ inputs} + N_2O\text{-}N_{OS} + N_2O\text{-}N_{PRP} \qquad (3C4)$$

Where:

$N_2O\text{-}N_{N\ inputs}$ = $[(F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \times EF_1] + [(F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \times EF_{1FR}]$

$N_2O\text{-}N_{OS}$ = $(F_{OS,CG,Temp} \times EF_{2CG,Temp}) + (F_{OS,CG,Trop} \times EF_{2CG,Trop}) + (F_{OS,F,Temp,NR} \times EF_{2F,Temp,NR}) + (F_{OS,F,Temp,NP} \times EF_{2F,Temp,NP}) + (F_{OS,F,Trop} \times EF_{2F,Trop})$

$N_2O\text{-}N_{PRP}$ = $(F_{PRP,CPP} \times EF_{3PRP,CPP}) + (F_{PRP,SO} \times EF_{3PRP,SO})$

N_2O Emission = $N_2O\text{-}N \times 44/28$

$N_2O_{Direct}\text{-}N$ = annual direct N_2O-N emissions produced from managed soils (kg N/year)

$N_2O\text{-}N_{N\ inputs}$ = annual direct N_2O-N emissions from N inputs to managed soils (kg N/year)

$N_2O\text{-}N_{OS}$ = annual direct N_2O-N emissions from managed organic soils (kg N/year) (CG = croplands and grasslands, F = forest lands, Temp = temperate, Trop = tropical, NR = nutrient rich, NP = nutrient poor)

$N_2O\text{-}N_{PRP}$ = annual direct N_2O-N emissions from urine and dung inputs to grazed soils (kg N/year)

F_{SN} = annual amount of synthetic fertilizer N applied to soils (kg N/year)

F_{ON} = annual amount of animal manure (F_{AM}), compost (F_{COMP}), sewage sludge (F_{SEW}) and other organic N additions (F_{OOA}) applied to soils (kg N/year)

$F_{ON} = F_{AM} + F_{SEW} + F_{COMP} + F_{OOA}$

F_{AM} = $N_{MMS\ Avb} \times [1 - (Frac_{FEED} + Frac_{FUEL} + Frac_{CNST})]$

$N_{MMS\ Avb}$ = amount of managed manure nitrogen available for application to managed soils or for feed, fuel, or construction purposes (kg N/year)

$$N_{MMS\ Avb} = \sum_S \left[\sum_T \begin{pmatrix} \left(\left(N_{(T)} \times Nex_{(T)} \times MS_{(T,S)} \right) \times \left(1 - \frac{Frac_{LossMS}}{100} \right) \right) \\ + \left(N_{(T)} \times MS_{(T,S)} \times N_{beddingMS} \right) \end{pmatrix} \right]$$

$N_{(T)}$ = number of head of livestock species/category T in the country (head)

$Nex_{(T)}$ = annual average N excretion per animal of species/category T in the country (kg N/head/year)

$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country

$Frac_{LossMS}$ = amount of managed manure nitrogen for livestock category T that is lost in the manure management system S (%)

$N_{beddingMS}$ = amount of nitrogen from bedding (to be applied for solid storage and deep bedding MMS if known organic bedding usage) (kg N/head/year)

S = manure management system

T = species/category of livestock

$Frac_{FEED}$ = fraction of managed manure used for feed

$Frac_{FUEL}$ = fraction of managed manure used for fuel

$Frac_{CNST}$ = fraction of managed manure used for construction

F_{CR} = annual amount of N in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually (kg N/year)

$$F_{CR} = \sum_T \left\{ \begin{matrix} Crop_{(T)} \times Frac_{Renew(T)} \times \\ \left[\left(Area_{(T)} - Area\ burnt_{(T)} \times C_f \right) \times R_{AG(T)} \times N_{AG(T)} \times \left(1 - Frac_{Remove(T)} \right) + Area_{(T)} \times R_{BG(T)} \times N_{BG(T)} \right] \end{matrix} \right\}$$

$Crop_{(T)}$ = harvested annual dry matter yield for crop T (kg dry matter/hectare) $Crop_{(T)} = Yield\ Fresh_{(T)} \times DRY$

$Yield\ Fresh_{(T)}$ = harvested fresh yield for crop T (kg fresh weight/hectare)

DRY = dry matter fraction of harvested crop T (kg dry matter/kg fresh weight)

$Area_{(T)}$ = total annual area harvested of crop T (hectare/year)

$Area\ burnt_{(T)}$ = annual area of crop T burnt (hectare/year)

C_f = combustion factor

$Frac_{Renew(T)}$ = fraction of total area under crop T that is renewed annually

$R_{AG(T)}$ = ratio of above-ground residues dry matter (AGDM(T)) to harvested yield for crop T (kg dry matter/kg dry matter)

$$R_{AG(T)} = \frac{AG_{DM(T)} \times 1000}{Crop_{(T)}}$$

$AG_{DM(T)}$ = above-ground residue dry matter (Mg/hectare)

$Frac_{Remove(T)}$	=	fraction of above-ground residues of crop T removed annually for purposes such as feed, bedding and construction (kg N/kg crop N)
T	=	crop or forage type
$R_{BG(T)}$	=	ratio of below-ground residues to harvested yield for crop T (kg dry matter/kg dry matter) $R_{BG(T)} = R_{BG\text{-}BIO} \times \frac{(AG_{DM(T)} \times 1000 + Crop_{(T)})}{Crop_{(T)}}$
$R_{BG\text{-}BIO}$	=	ratio of below-ground residues to above-ground biomass
$N_{AG(T)}$	=	N content of above-ground residues for crop T (kg N/kg dry matter)
$N_{BG(T)}$	=	N content of below-ground residues for crop T (kg N/kg dry matter)
F_{SOM}	=	the net annual amount of N mineralised in mineral soils as a result of loss of soil carbon through change in land use or management (kg N) $F_{SOM} = \sum_{LU}\left[\left(\Delta C_{Mineral,LU} \times \frac{1}{R}\right) \times 1000\right]$
$\Delta C_{Mineral,LU}$	=	average annual loss of soil carbon for each land-use type (LU) (tonnes C)
R	=	C:N ratio of the soil organic matter
LU	=	land-use and/or management system type
EF_1	=	emission factor for N_2O emissions from N inputs (kg N_2O-N/kg N input)
EF_{1FR}	=	emission factor for N_2O emissions from N inputs to flooded rice (kg N_2O-N/kg N input)
F_{OS}	=	annual area of managed/drained organic soils (hectare)
EF_2	=	emission factor for N_2O emissions from drained/managed organic soils (kg N_2O-N/hectare/year)
F_{PRP}	=	$\sum_T\left[\left(N_{(T)} \times Nex_{(T)}\right) \times MS_{(T,PRP)}\right]$ (CPP = cattle, poultry and pigs; SO = sheep and other animals)
EF_{3PRP}	=	emission factor for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals (kg N_2O-N/kg N input)

Activity Data for Direct N_2O emissions from managed soils (3C4)

The activity data for GHG emissions in this subcategory includes various nitrogen sources: nitrogen from chemical fertilizers (F_{SN}), nitrogen from organic fertilizers (F_{ON}), nitrogen from agricultural residues (F_{CR}), nitrogen released from the decomposition of organic matter in the soil (F_{SOM}), the area of organic land under cultivation (F_{OS}), and nitrogen from urine and manure from livestock (F_{PRP}). The details of each activity are as follows:

1) Nitrogen from synthetic fertilizers (F_{SN})

The nitrogen content from chemical fertilizers applied to agricultural soil was estimated based on the amount of imported and exported chemical fertilizers, assuming that all fertilizers were used in cultivated areas. The data source for this activity was the Department of Agriculture, and the information used in this assessment is presented below (Table 2-120).

Table 2-120: Imported and exported chemical fertilizers for 2020-2022

Year	Imported chemical fertilizers (tonnes)	Exported chemical fertilizers (tonnes)	N fertilizer applied (tonnes)
2020	5,056,207.69	536,865.19	1,203,543
2021	5,520,883.14	707,459.37	1,145,406
2022	4,103,668.56	407,174.94	902,419

2) Nitrogen from organic matter applied as fertilizer (F_{ON})

This data includes nitrogen from several sources: livestock manure applied to the soil (F_{AM}), nitrogen from sludge (F_{SEW}), nitrogen from compost (F_{COMP}), and nitrogen from organic materials used as fertilizer substitutes (F_{OOA}). A review of national data reveals that the quantities of sludge, compost, and organic materials used as substitutes in cultivated areas are minimal, and there is no direct reporting of these amounts. As a result, this assessment will focus solely on nitrogen from livestock manure applied to the soil (F_{AM}).

Nitrogen from animal manure applied to the soil (F_{AM}) refers to the nitrogen content derived from manure within the manure management system (excluding grazing animals) that is used in cultivated areas. The activity data required for this assessment is similar to that used for estimating N_2O emissions in sector 3B Manure Management, which includes animal population ($N_{(T)}$), nitrogen excretion rate per head ($N_{ex(T)}$), and the proportion of manure in different management systems (MS). Supplementary information includes the proportion of nitrogen lost from manure management in each system ($Frac_{LossMS}$), which is based on defaults from the 2006 IPCC GLs. Details of these values are presented in Table 2-121.

Table 2-121: $Frac_{LossMS}$ from the 2006 IPCC GLs used in this inventory

Livestock	$Frac_{LossMS}$ (%)						
	Daily spread	Solid storage	Dry lot	Poultry litter		Anaerobic lagoon	Deep bedding
				With bedding	Without bedding		
Dairy cattle	22	40	30			77	
Beef cattle and buffalo		50	40				40
Swine		50				78	50
Poultry				50	55	77	
Others		15					35

3) Nitrogen from crop residues (F_{CR})

The amount of nitrogen from crop residues was assessed using the same activity data as in subcategory 3C Field burning of agricultural residues. This includes the production and harvested area by crop, the fraction (burnt, removed and left) and the combustion factor. Other required information was obtained from the defaults according to the 2006 IPCC GLs.

4) Nitrogen from urine and dung N deposited on pasture, range and paddock by grazing animals (F_{PRP})

The nitrogen from grazing livestock was assessed using the same activity data required for estimating N_2O emissions in subcategory 3B Manure Management. This includes the animal population ($N_{(T)}$), nitrogen excretion rate per head ($N_{ex(T)}$), and the proportion of manure in grazing systems ($MS_{(T,PRP)}$).

5) Mineralised N resulting from loss of soil organic carbon stocks in mineral soils through land-use change or management practices (F_{SOM})

Nitrogen released from the decomposition of organic matter in mineral soils results from carbon loss in the soil due to land use and management practices. The assessment relies on data regarding average carbon loss in soil from land use. However, a review of national data revealed no reported information, making it impossible to estimate GHG emissions in this area.

6) Drained/managed organic soils (F_{OS})

National data indicates that the area of organic land used for agriculture in Thailand is very small compared to the areas cultivated for various economic crops. As such, emissions from this activity will not be assessed.

Emission Factors for Direct N_2O emissions from managed soils (3C4)

The emission factors for assessing GHG emissions in this subcategory are categorized into EF_1 and EF_{1FR} for synthetic fertilizers, animal manures, and crop residues and EF_{3PRP} for urine and dung N deposited on pasture, range and paddock by grazing animals. In this inventory, Tier 1 assessment was applied from the 2006 IPCC GLs (Table 2-122).

Table 2-122: N_2O EFs for direct emissions from managed soils (the 2006 IPCC GLs)

EFs	Defaults
EF_{1FR} from N inputs to flooded rice (kg N_2O-N/kg N input)	0.003
EF_1 from N inputs (kg N_2O-N/kg N input)	0.01
EF_{3PRP} from urine and dung N deposited on pasture, range and paddock by grazing animals (kg N_2O-N/kg N input): dairy cattle, beef cattle, buffalo, swine and poultry	0.02
EF_{3PRP} from urine and dung N deposited on pasture, range and paddock by grazing animals (kg N_2O-N/kg N input): sheep and others	0.01

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of Direct N_2O Emissions from Managed Soils (3C4), the uncertainties indicated in the 2006 IPCC Guidelines (-269.13% to +269.13% for N_2O) were adopted. Since the values in the annual report of several sources, e.g., the Department of Agriculture, were used for the activity data, default values in the 2006 IPCC Guidelines were not available. Therefore, the uncertainty of the emissions from Direct N_2O emissions from managed soils was estimated as -269.13% to +269.13% for N_2O.

Time-series Consistency

The activity data of Direct N_2O Emissions from Managed Soils given in the annual report of several sources, e.g., the Department of Agriculture, are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

Emissions estimated for Direct N_2O Emissions from Managed Soils (3C4) follow Tier 1 approaches. Capacity building and support are needed to develop a Tier 2 approach for Direct N_2O emissions from managed soils (if appropriate).

Estimated Emissions from Direct N_2O Emissions from Managed Soils (3C4)

The assessment of direct N_2O Emissions from Agricultural Soils for 2020–2021 revealed that the highest emissions originated from the application of chemical fertilizers. This was followed by emissions from livestock manure, with agricultural residues contributing the least (Table 2-123).

Table 2-123: N_2O emissions from direct emissions of managed soils for 2020-2022

Year	N_2O emissions ($ktCO_2eq$)				
	F_{SN}	F_{AM}	F_{PRP}	F_{CR}	Sum
2020	3,674.62	1,134.67	1,418.12	1,214.24	7,441.65
2021	3,311.14	1,271.98	1,703.70	1,382.74	7,669.56
2022	2,274.29	1,297.27	1,999.45	1,390.77	6,961.78

Direct N_2O emissions from agricultural soils between 2000 and 2022 have exhibited a consistent upward trend, primarily driven by the use of synthetic fertilizers. However, between 2021 and 2022, N_2O emissions decreased. This fluctuation can be attributed to several factors, including changes in fertilizer prices and agricultural product prices. Such variations may have influenced fertilizer application rates and prompted shifts in agricultural practices (Figure 2-64).

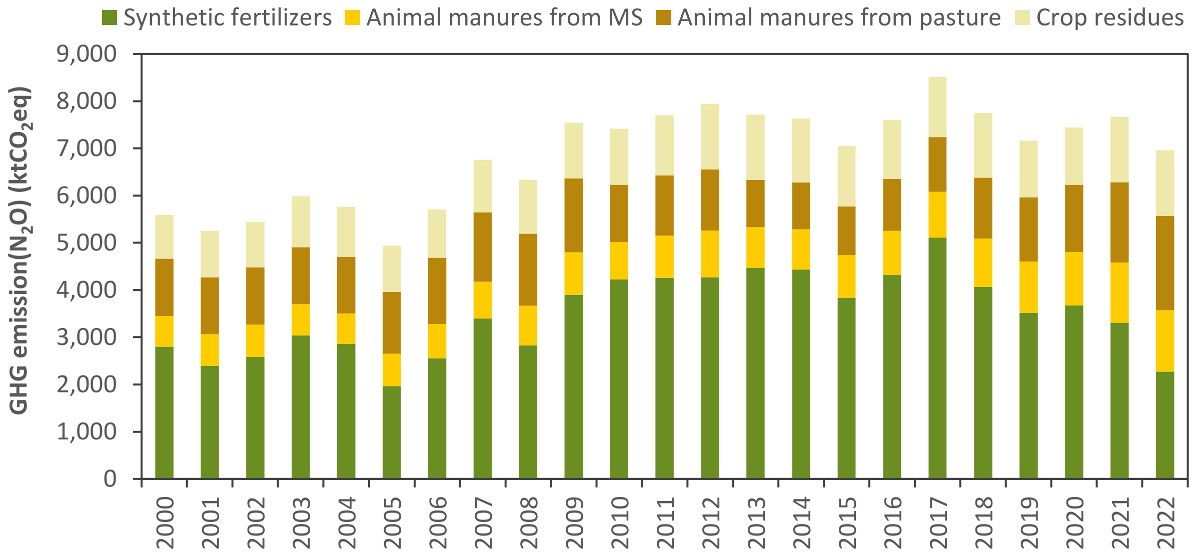
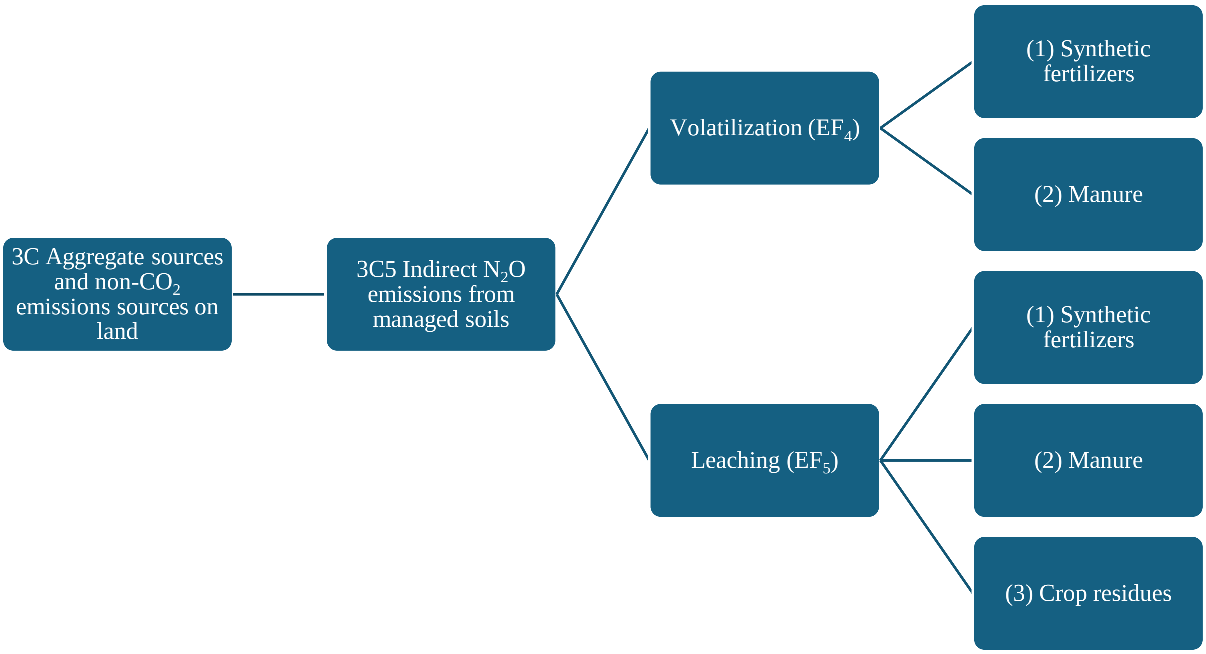


Figure 2-64: Direct N_2O emissions from agricultural soils during 2000-2022

Indirect N_2O emissions from managed soils (3C5)

Category Description

Indirect N_2O emissions from N applied to managed soils occur via two pathways: (1) volatilisation of N as NH_3 and oxides of N (NO_x), and (2) the deposition of these gases and their products NH_4^+ and NO_3^- onto soils and the surface of lakes and other waters. In Thailand, Tier 1 methodology is applied to estimate indirect N_2O emissions from soil.



Estimation Method

$$N_2O_{(ATD)}\text{-}N = [(F_{SN} \times Frac_{GASF}) + ((F_{ON} + F_{PRP}) \times Frac_{GASM})] \times EF_4 \qquad (3C5\text{-}1)$$

Where:

$N_2O_{(ATD)}$-N = annual amount of N_2O–N produced from atmospheric deposition of N volatilised from managed soils (kg N/year)

F_{SN} = annual amount of synthetic fertilizer N applied to soils (kg N/year)

$Frac_{GASF}$ = fraction of synthetic fertilizer N that volatilises as NH_3 and NO_x (kg N volatilized/kg of N applied)

F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils (kg N/year)

F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock (kg N/year)

$Frac_{GASM}$ = fraction of applied organic N fertilizer materials (F_{ON}) and of urine and dung N deposited by grazing animals (F_{PRP}) that volatilises as NH_3 and NO_x (kg N volatilised/kg of N applied)

EF_4 = emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces (kg N_2O-N/kg NH_3-N and NO_x-N emitted)

$$N_2O_{(L)}\text{-}N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) \times Frac_{LEACH-(H)} \times EF_5 \quad (3C5\text{-}2)$$

Where:

$N_2O_{(L)}$-N = amount of N_2O–N produced from leaching and runoff of N additions to managed soils in regions where leaching/runoff occurs (kg N/year)

F_{SN} = annual amount of synthetic fertilizer N applied to soils in regions where leaching/runoff occurs (kg N/year)

F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils in regions where leaching/runoff occurs (kg N/year)

F_{PRP} = annual amount of urine and dung N deposited by grazing animals in regions where leaching/runoff occurs (kg N/year)

F_{CR} = amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually in regions where leaching/runoff occurs (kg N/year)

F_{SOM} = annual amount of N mineralised in mineral soils associated with loss of soil C from soil organic matter as a result of changes to land use or management in regions where leaching/runoff occurs (kg N/year)

$Frac_{LEACH-(H)}$= fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff (kg N/kg N applied)

EF_5 = emission factor for N_2O emissions from N leaching and runoff (kg N_2O-N/kg N leaching & runoff)

Activity Data for Indirect N_2O Emissions from Managed Soils (3C5)

Activity data from subcategory Direct Emissions (3C4) were similarly utilized for assessments in this subcategory.

Emission Factors for Indirect N_2O Emissions from Managed Soils (3C5)

EFs for indirect N_2O emissions were adopted from the 2006 IPCC GLs (Table 2-124).

Table 2-124: Fractions of N loss from managed soils and emission factors for indirect N_2O emissions from managed soils

Fractions of N loss from managed soils and emission factors	IPCC default
$Frac_{GASF}$ (volatilisation from synthetic fertilizer) (kg NH_3–N + NO_x–N/kg N applied)	0.10
$Frac_{GASM}$ (volatilisation from all organic N fertilizers applied , and dung and urine deposited by grazing animals (kg NH_3–N + NO_x–N/kg N applied)	0.20
$Frac_{LEACH-H}$ (N losses by leaching/runoff for regions where Σ(rain in rainy season) - Σ (PE in same period) > soil water holding capacity, or where irrigation (except drip irrigation) is employed) (kg N/kg N additions or deposition by grazing animals)	0.30
EF_4 (N volatilisation and re-deposition) (kg N_2O-N/kg NH_3-N+NO_X-N)	0.01
EF_5 (leaching/runoff) (kg N_2O-N/kg N leaching/runoff)	0.0075

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of Indirect N_2O Emissions from Managed Soils (3C5), the uncertainties indicated in the 2006 IPCC Guidelines (-463.60% to +463.60% for N_2O) were adopted. Since the values in the annual report of several sources, e.g., the Department of Agriculture, were used for the activity data, default values in the 2006 IPCC Guidelines were not available. Therefore, the uncertainty of the emissions from Direct N_2O emissions from managed soils was estimated as -463.60% to +463.60% for N_2O.

Time-series Consistency

The activity data of Indirect N_2O Emissions from Managed Soils given in the annual report of several sources, e.g., the Department of Agriculture, are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

Emissions estimated for Indirect N_2O Emissions from Managed Soils (3C5) follow Tier 1 approaches. Capacity building and support are needed to develop a Tier 2 approach for Direct N_2O emissions from managed soils (if appropriate).

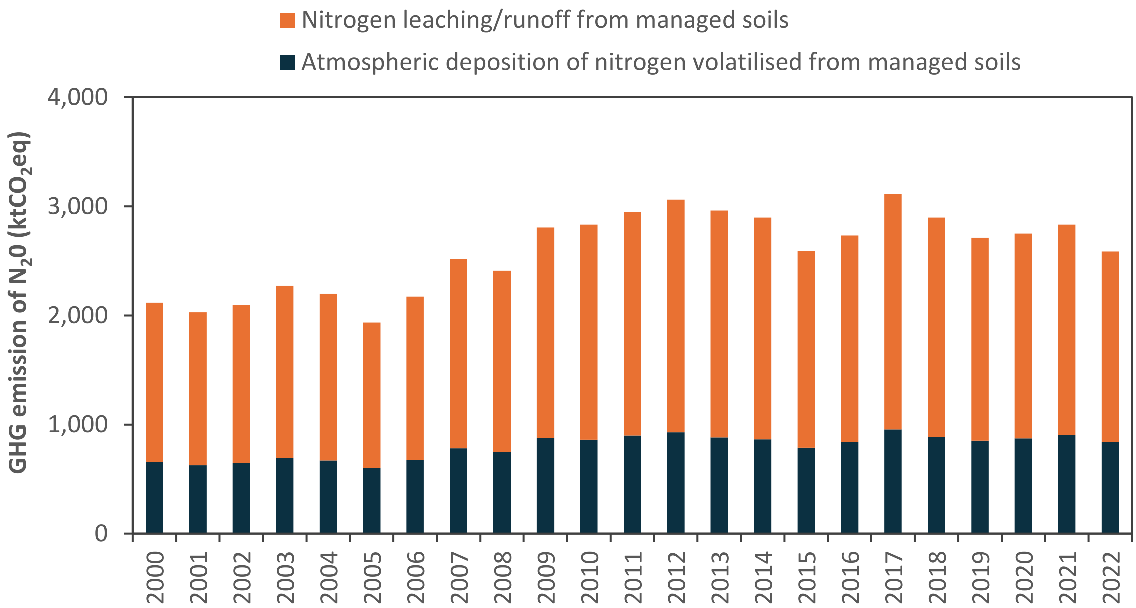
Estimated Emissions from Indirect N_2O Emissions from Managed Soils (3C5)

The assessment of indirect N_2O emissions from agricultural soils during 2020–2021 revealed that the main source of GHG emissions was leaching and surface runoff (68%) and atmospheric deposition contributed 32% of the total emissions (Table 2-125).

Table 2-125: N_2O emissions from indirect emissions of managed soils for 2020-2022

Year	N_2O emissions ($ktCO_2eq$)		
	Atmospheric deposition of nitrogen volatilised from managed soils	Nitrogen leaching/runoff from managed soils	Sum
2020	871.09	1,878.47	2,749.56
2021	903.28	1,930.38	2,833.66
2022	837.00	1,748.40	2,585.40

Indirect N_2O emissions from agricultural soils between 2000 and 2022 exhibited a trend similar to that of direct N_2O emissions. Specifically, N_2O emissions showed a continuous increase over the years, followed by a decline between 2021 and 2022. The primary sources of these emissions were leaching and surface runoff. Additionally, when categorizing N_2O emissions by activity, it becomes clear that the main contributing factor is the use of chemical fertilizers, aligning with findings in subcategory 3F Direct N_2O emissions from agricultural lands (Figure 2-65).



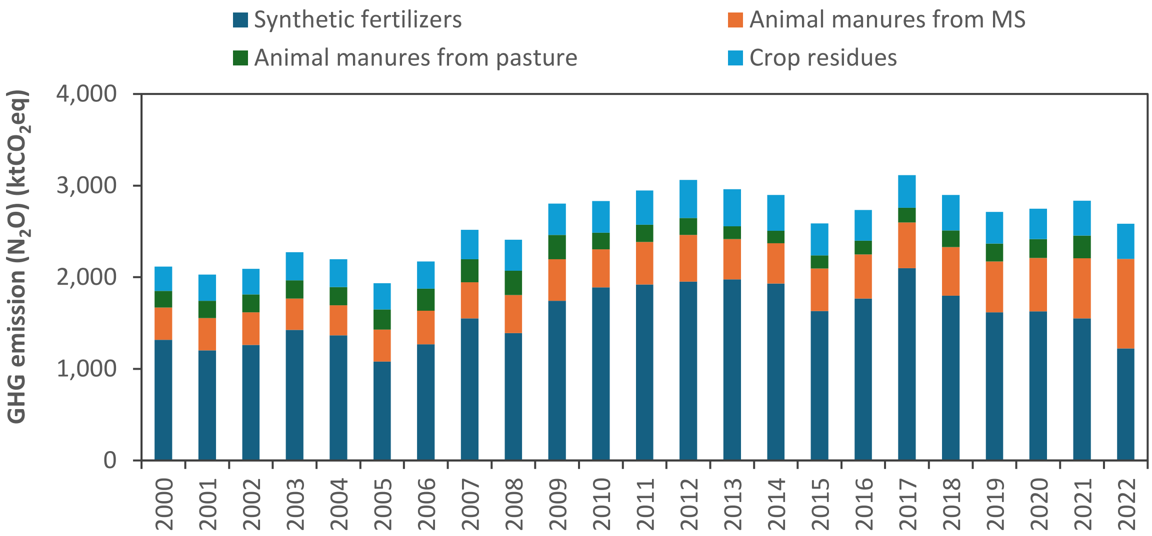
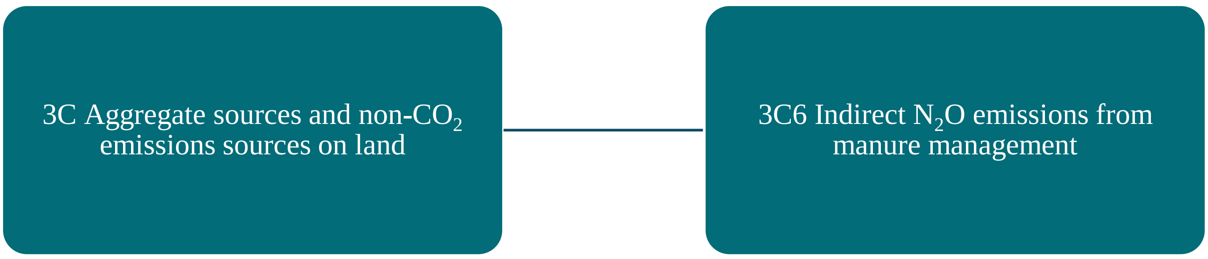


Figure 2-65: Indirect N_2O emissions from agricultural soils for 2000-2022

Indirect N_2O emissions from manure management (3C6)

Category Description

Indirect N_2O emissions from manure management system occur via two pathways: (1) volatilisation of N as NH_3 and oxides of N (NO_x) and (2) the deposition of these gases and their products NH_4^+ and NO_3^- onto soils and the surface of lakes and other waters. In Thailand, Tier 2 methodology is applied to estimate indirect N_2O emissions from manure management. Only N_2O emission from N volatilization of manure management system is estimated.



Estimation Method

$$N_2O_{G(mm)} = (N_{volatilization\text{-}MMS} \times EF_4) \times \frac{44}{28} \qquad (3C6)$$

Where:

$N_2O_{G(mm)}$ = indirect N_2O emissions due to volatilization of N from Manure Management in the country (kg N_2O/year)

$N_{volatilization\text{-}MMS}$ = amount of manure nitrogen that is lost due to volatilisation of NH_3 and NO_x (kg N/year)

$$N_{volatilization\text{-}MMS} = \sum_S \left[\sum_T \left[\left(N_{(T)} \times Nex_{(T)} \times MS_{(T,S)}\right) \times \left(\frac{Frac_{GasMS}}{100}\right)_{(T,S)}\right]\right]$$

$N_{(T)}$ = number of head of livestock species/category T in the country (head)

$Nex_{(T)}$ = annual average N excretion per animal of species/category T in the country (kg N/head/year)

$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country

$Frac_{GasMS}$ = percent of managed manure nitrogen for livestock category T that volatilises as NH_3 and NO_x in the manure management system S (%)

EF_4 = emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces (kg N_2O-N/kg NH_3-N and NO_x-N volatilized)

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

Activity Data for Indirect N_2O Emissions from Manure Management (3C6)

Activity data used to assess indirect N_2O emissions from manure management includes the following: animal population ($N_{(T)}$), nitrogen excretion rate per head ($N_{ex(T)}$), and the proportion of manure in various management systems (MS). This data set aligns with that used in subcategory 3B Manure Management and 3F Direct N_2O Emissions from Agricultural Soils. Only the proportion of nitrogen from manure lost as NH_3 and NO_x under manure management systems ($Frac_{GASMS}$) is utilized in this inventory, which is based on defaults from the 2006 IPCC GLs (Table 2-126).

Table 2-126: $Frac_{GASMS}$ from the 2006 IPCC GLs used in this inventory

Livestock	$Frac_{GASMS}$ (%)						
	Daily spread	Solid storage	Dry lot	Poultry litter		Anaerobic lagoon	Deep bedding
				With bedding	Without bedding		
Dairy cattle	7	30	20			35	
Beef cattle and buffalo		45	30				30
Swine		45				40	40
Poultry				40	55	40	
Others		12					25

Emission Factors for Indirect N_2O Emissions from Manure Management (3C6)

EF_4 for indirect N_2O emissions were also adopted from the 2006 IPCC GLs, as mentioned in the previous section.

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of Indirect N_2O Emissions from Manure Management (3C6), the uncertainties indicated in the 2006 IPCC Guidelines (-423.25% to +423.25% for N_2O) were adopted. Since the values in the annual report of several sources, e.g., the Department of Agriculture, were used for the activity data, default values in the 2006 IPCC Guidelines were not available. Therefore, the uncertainty of the emissions from Indirect N_2O emissions from Manure Management was estimated as -426.66% to +426.66% for N_2O.

Time-series Consistency

The activity data of Indirect N_2O Emissions from Manure Management given in the annual report of the Department of Livestock Development, are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

Emissions estimated for Indirect N_2O Emissions from Manure Management (3C6) follow Tier 1 approaches. Capacity building and support are needed to develop a Tier 2 approach for Indirect N_2O Emissions from Manure Management (if appropriate).

Estimated Emissions from Indirect N_2O Emissions from Manure Management (3C6)

The assessment of indirect N_2O emissions from manure management in the years 2020-2022 indicated that the majority of greenhouse gas emissions originated from poultry, followed by beef cattle. A summary of GHG emissions categorized by animal type is presented below (Table 2-127).

Table 2-127: Indirect N_2O emissions from manure management in the year 2020-2022

Year	Indirect N_2O emissions ($ktCO_2eq$)							
	Dairy cattle	Beef cattle	Buffalo	Swine	Goat	Sheep	Poultry	Sum
2020	27.18	172.25	39.79	33.14	5.92	0.41	259.26	537.95
2021	30.77	211.11	47.96	35.90	7.85	0.55	269.95	604.07
2022	30.72	265.71	55.31	28.86	9.25	0.63	277.41	667.90

Indirect N_2O emissions from manure management between 2000 and 2022 have shown a consistent upward trend, with poultry and beef cattle being the main sources of GHG emissions. Beef cattle were the largest contributors to GHG emissions from 2000 to 2010; however, the continuous increase in poultry populations, particularly broiler chickens, has made poultry the largest group contributing to greenhouse gas emissions in this sector since 2011, as shown below (Figure 2-66).

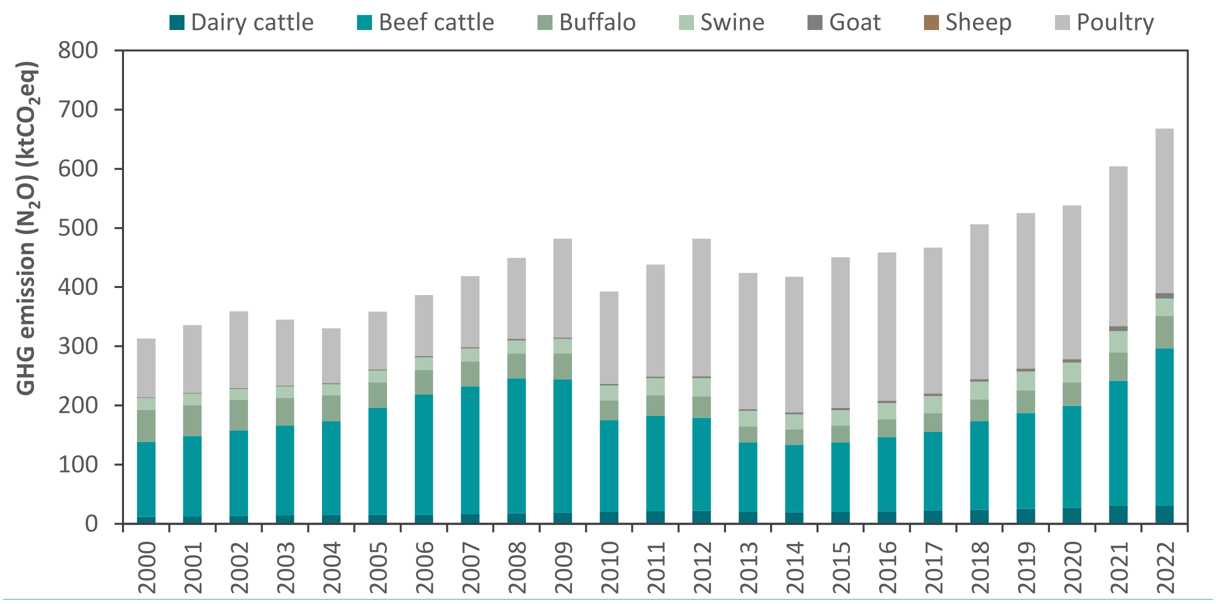
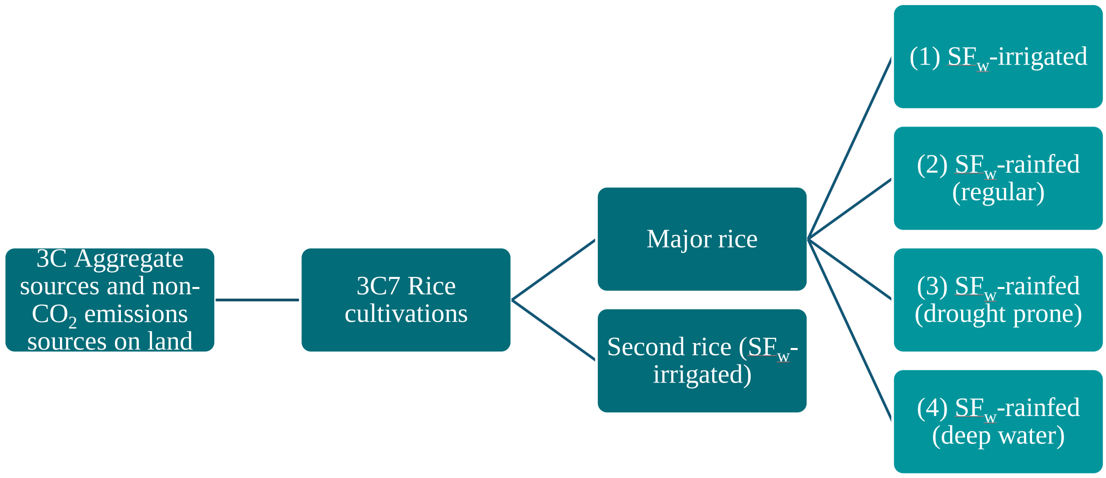


Figure 2-66: Indirect N_2O emissions from manure management during 2000-2022

Rice cultivation (3C7)

Category Description

In flooded rice fields, organic material in soils is anaerobically decomposed and CH_4 is produced and emitted. Important influencing factors in rice CH_4 emission are the number and duration of crops grown, water regimes before and during cultivation period, and organic and inorganic soil amendments. In addition, soil type, temperature, and rice cultivar also influence CH_4 emissions. In Thailand, the Tier 2 methodology is applied to estimate CH_4 emissions from rice cultivation.



Estimation Method

$$CH_{4\ Rice} = \sum_{i,j,k}\left(EF_{i,j,k} \times t_{i,j,k} \times A_{i,j,k} \times 10^{-6}\right) \quad (3C7\text{-}1)$$

$$EF_i = EF_c \times SF_w \times SF_p \times SF_o \times SF_{s,r} \quad (3C7\text{-}2)$$

Where:

$CH_{4\ Rice}$ = annual methane emissions from rice cultivation (Gg CH_4/year)

EF_{ijk} = a daily emission factor for i, j and k conditions (kg CH_4/hectare/day) (i, j, k = ecosystem, water regimes, type and amount of organic amendments, and other conditions under which CH_4 emissions from rice may vary)

t_{ijk} = cultivation period of rice for i, j and k conditions (day)

A_{ijk} = annual harvested area of rice for i, j and k conditions (hectare/year)

EF_i = adjusted daily emission factor for a particular harvested area (kg CH_4/hectare/day)

EF_c = baseline emission factor for continuously flooded fields without organic amendments (kg CH_4/hectare/day)

SF_w = scaling factor to account for the differences in water regime during the cultivation period

SF_p = scaling factor to account for the differences in water regime in the pre-season before the cultivation period

$SF_{s,r}$ = scaling factor for soil type, rice cultivar, etc., if available

SF_o = scaling factor should vary for both type and amount of organic amendment applied

$$SF_o = \left(1+\sum_i ROA_i \times CFOA_i\right)^{0.59}$$

ROA_i = application rate of organic amendment i, in dry weight for straw and fresh weight for others (tonne/hectare)

$CFOA_i$ = conversion factor for organic amendment i (in terms of its relative effect with respect to straw applied shortly before cultivation)

Activity Data for Rice Cultivation (3C7)

Activity data for assessing CH_4 emissions from rice cultivation focuses on the harvested area of rice (A), categorized by rice ecosystems (Table 2-128). This classification follows the definitions outlined in the 2006 IPCC GLs, composed of upland rice, irrigated rice, and rainfed rice (flood-prone, drought-prone, and deep-water). The Office of Agricultural Economics provides the data on harvested rice areas of major and second rice, classified by irrigated and non-irrigated areas. Irrigated rice fields are designated to include the harvested area of major (wet season) rice within irrigated regions and the second (dry season) rice. The harvested area of rice outside of irrigated regions is classified as rainfed rice and upland rice. The proportion of rainfed rice (flood and drought prone) is calculated based on soil survey data from the Department of Land Development, classified according to soil series for flood prone and drought prone. For deep water rice, the area is reported by the Rice Department, amounting to 62,236.32 hectares, while upland rice is assumed to equal the area of seed dropping (Table 2-129).

Table 2-128: The harvested area of rice classified by irrigated area for 2020-2022

Year	Harvested area of rice (ha)						
	Major rice			Second rice			Grand total
	Irrigated area	Outside irrigated area	Sum	Irrigated area	Outside irrigated area	Sum	
2020	2,411,324	7,203,682	9,615,006	1,394,570	400,720	1,155,289	10,770,296
2021	2,494,680	7,147,127	9,641,807	903,483	425,660	1,329,143	10,970,949
2022	2,503,676	7,015,016	9,518,692	1,068,246	454,603	1,522,848	11,041,540

Table 2-129: The harvested area of rice classified by cultivation methods for 2020-2022

Year	Harvested area of major rice (ha)				
	Transplanting	Dry seeding	Wet direct seeded rice	Seed dropping	Sum
2020	1,294,151	5,385,443	2,703,814	231,599	9,615,006
2021	1,448,165	5,232,710	2,761,900	199,032	9,641,807
2022	1,423,827	5,112,085	2,788,252	194,527	9,518,692

Emission Factors for Rice Cultivation (3C7)

For Thailand's GHG inventory, emission factors (EFs) for rice cultivation are country-specific and derived from relevant research articles and reports conducted within the country. CH_4 emission factors (EF_i) are categorized by rice ecosystems. The EF_i is calculated from the baseline CH_4 emission factor for continuously flooded fields without organic amendments (EF_c), multiplied by various scaling factors (SF) and cultivation duration. This includes the scaling factor for the water regime during the cultivation period (SF_w). Additionally, the CH_4 emission factors for rice are categorized by the northern, northeastern, central, and southern regions of Thailand, based on research data that consider key characteristics of the cultivation areas, including climate, soil, and agroecosystem conditions. Since the application of organic fertilizers is minimal compared to chemical fertilizers, only the emission values for rice fields using chemical fertilizers are reported. The qualified data used to estimate country-specific emission factors for rice cultivation are screened based on several requirements. These requirements include conducting the experiment in the field and in Thailand, and similar CH_4 measurements were performed by using chamber methods and measuring CH_4 emissions routinely, e.g., at least once or twice a week. According to these criteria, supporting data for the Tier 2 emission factor are derived from literature reviews of more than 20 national and international articles from proceedings and journals (Table 2-130).

Table 2-130: Rice CH_4 EFs for Thailand's Agriculture sector

Region	Rice CH_4 EF (kg/ha/season)					
	Major rice					Second rice
	Irrigated	Rainfed (flood-prone)	Rainfed (drought-prone)	Deep water	Upland	
Northern and northeastern	164	218.1	78.7	97.5	-	162.6
Central and southern	143	190.2	68.6	97.5	-	71.8

Uncertainties

Since the default values in the 2006 IPCC Guidelines were adopted for the emission factors of Rice Cultivation (3C7), the uncertainties indicated in the 2006 IPCC Guidelines (-122.89% to +122.89% for CH_4) were adopted. Since the values in the annual report of the Office of Agricultural Economics were used for the activity data, default values in the 2006 IPCC Guidelines were not available. Therefore, the uncertainty of the emissions from Rice Cultivation was estimated as -122.89% to +122.89% for CH_4.

Time-series Consistency

The activity data of Rice Cultivation given in the annual report of the Office of Agricultural Economics are used as activity data consistently throughout the time series. The same methods and a consistent approach to activity data and emission factors for each reported year are used throughout the time series. A consistent annual time series starting from 2000, covering the reference year of 2005 for Thailand's NDC, is reported.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials. In addition, a basic expert peer review of estimated emissions in accordance with the IPCC guidelines has been conducted in the QA procedures.

Category-specific Planned Improvements

Emissions estimated for Rice Cultivation (3C7) follow Tier 2 approaches. The methods used to classify rice cultivation areas into various ecosystems should be revised to incorporate modern technologies and advancements (if appropriate). CH_4 emission factors (EFs) for rice cultivation should be updated to reflect the increased availability of EFs and scaling factors for water management practices (SF_w), such as alternative wetting and drying (AWD).

Estimated Emissions from Rice Cultivation (3C7)

CH_4 emissions from rice cultivation for 2020-2022 showed that the majority of emissions originated from major rice areas, primarily from rainfed rice, followed by irrigated rice. This corresponds to the fact that most rice cultivation occurs during the wet season, with rainfed rice being predominant in Thailand. Furthermore, irrigated rice in the wet season produced more CH_4 than dry season rice, largely due to the greater cultivated area during the wet season. (Table 2-131).

Table 2-131: CH_4 emissions from rice cultivation for 2020-2022

Year	Rice CH_4 emissions ($ktCO_2eq$)							
	Major rice						Second rice	Grand total
	Irrigated	Flood-prone rainfed	Drought-prone rainfed	Deep water	Upland	Sum		
2020	10,460.55	4,591.87	13,482.49	161.84	-	28,696.74	4,019.64	32,716.39
2021	10,819.76	4,538.14	13,457.70	161.49	-	28,977.09	4,654.51	33,631.60
2022	10,853.23	4,528.50	13,181.36	161.02	-	28,724.11	5,162.68	33,886.79

CH_4 emissions from rice cultivation between 2000 and 2022 exhibited a generally consistent trend, with a significant increase observed from 2010 to 2014. This increase can be attributed to the relatively stable rice cultivation areas, which did not change much during the assessed period. The heightened emissions during those years were likely influenced by external factors, such as rising rice prices, which incentivized greater cultivation (Figure 2-67).

Annual fluctuations in emissions are primarily due to variations in climatic conditions, including natural disturbances like droughts, floods, and irregular rainfall patterns. This volatility is particularly evident in dry season rice cultivation, which takes place during a period marked by increased risks, especially related to climate.

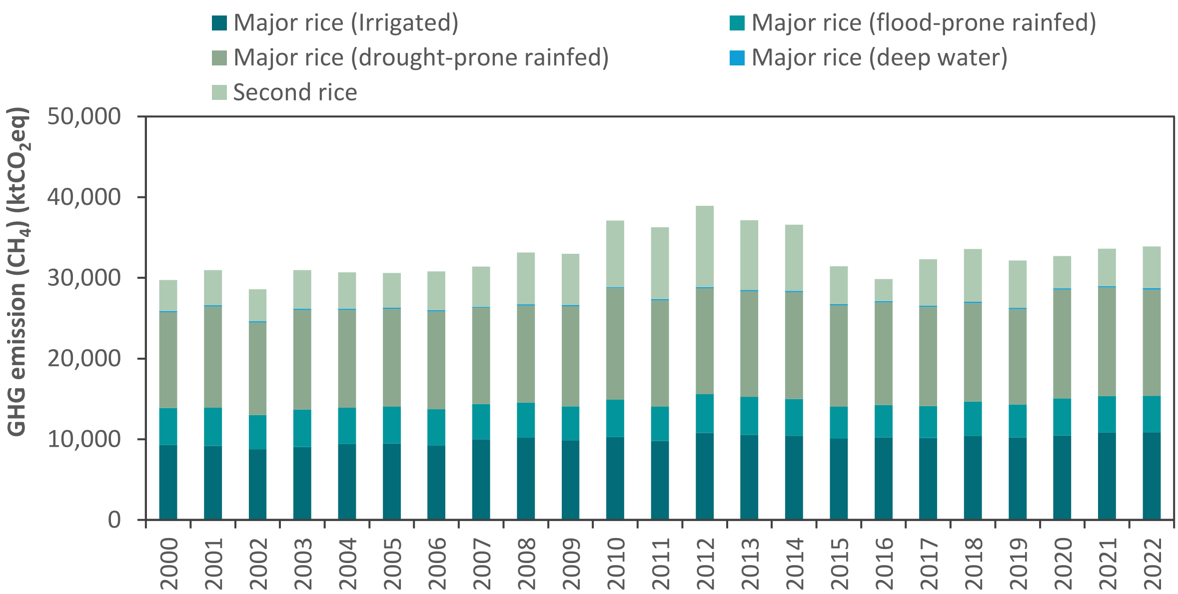


Figure 2-67: CH_4 emissions from rice cultivation for 2000-2022

Greenhouse Gas Emissions in Agriculture Sector in 2020

Total GHG emissions from the agriculture sector in 2020 were 62,065.69 $ktCO_2eq$. Livestock contributed 16,301.99 $ktCO_2eq$ (26.27%), comprising 12,754.08 $ktCO_2eq$ from enteric fermentation, 3,009.97 and 537.95 $ktCO_2eq$ for direct and indirect manure management, respectively. Meanwhile, crop related-GHG emissions accounted for 45,763.69 $ktCO_2eq$ (73.73%). Rice cultivation was the main GHG contributor in Thailand's agriculture sector, at 32,716.39 $ktCO_2eq$ (52.71 %). Agricultural soils emitted 10,191.22 $ktCO_2eq$ (16.42%) with direct and indirect emissions contributing 7,441.65 and 2,749.56 $ktCO_2eq$, respectively. Urea fertilizer and field burning of agricultural residues contributed similar GHG emissions of 1,435.18 and 1,404.31 $ktCO_2eq$ (2.31 and 2.26%), respectively. The lowest agricultural GHG emission in 2020 was from liming (16.60 $ktCO_2eq$ or 0.03%). Details of 2020 GHG emissions in the agriculture sector by gas type and source are presented below (Figure 2-68 and Table 2-132).

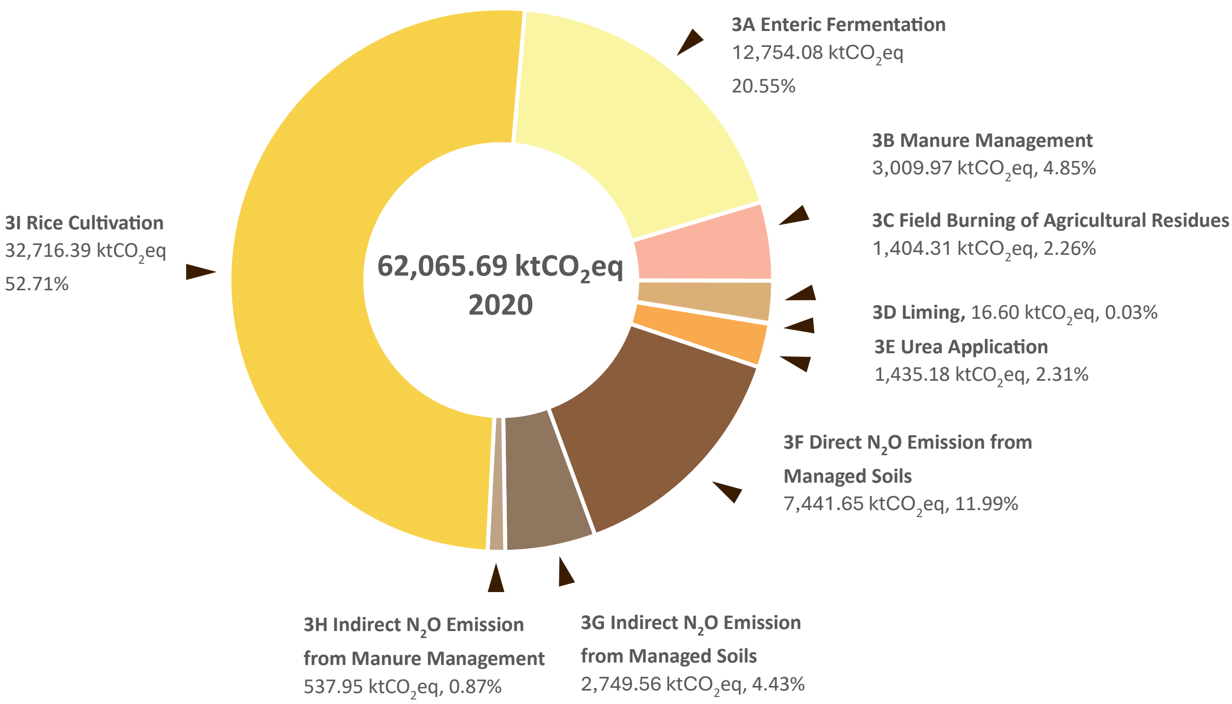


Figure 2-68: GHG emissions in Agriculture sector in 2020

Greenhouse Gas Emissions in Agriculture Sector in 2021

Total GHG emissions from the agriculture sector in 2021 were 66,503.31 $ktCO_2eq$. Livestock contributed 19,440.90 $ktCO_2eq$ (29.23%), comprising 15,364.76 $ktCO_2eq$ from enteric fermentation, 3,472.08 and 604.07 $ktCO_2eq$ for direct and indirect manure management, respectively. Meanwhile, crop related-GHG emissions accounted for 47,062.41 $ktCO_2eq$ (70.77%). Rice cultivation was the main GHG contributor in Thailand's Agriculture sector, at 33,631.60 $ktCO_2eq$ (50.57%). Agricultural soils emitted 10,503.23 $ktCO_2eq$ (15.79%) with direct and indirect emissions contributing 7,669.56 and 2,833.66 $ktCO_2eq$, respectively. Field burning of agricultural residues and urea fertilizer contributed similar GHG emissions of 1,617.03 and 1,294.18 $ktCO_2eq$ (2.43 and 1.95%), respectively. The lowest agricultural GHG emission in 2021 was from liming (16.37 $ktCO_2eq$ or 0.02%). Details of 2021 GHG emissions in the agriculture sector by gas type and source are presented below (Figure 2-69 and Table 2-133).

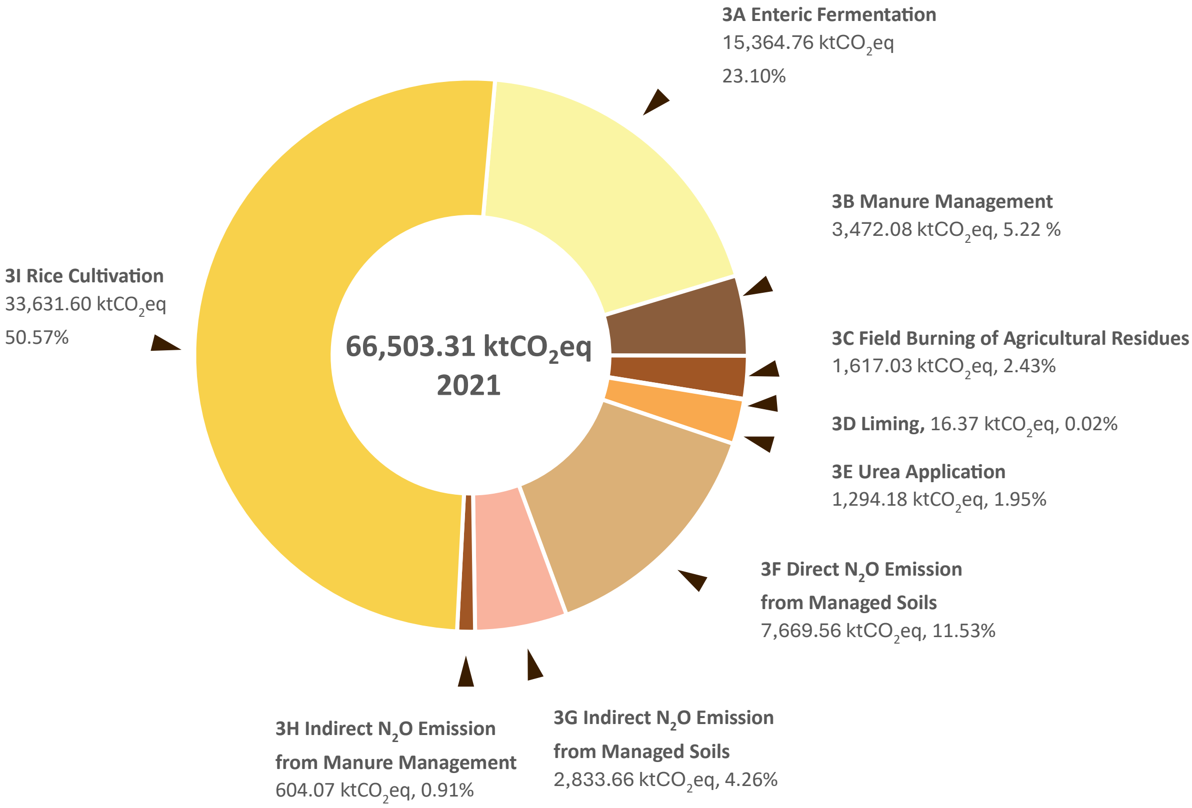


Figure 2-69: GHG emissions in Agriculture sector in 2021

Greenhouse Gas Emissions in Agriculture Sector in 2022

Total GHG emissions from the agriculture sector in 2022 were 68,933.74 ktCO_2eq. Livestock contributed 22,745.15 ktCO_2eq (33.04%), comprising 18,347.24 ktCO_2eq from enteric fermentation, 3,730.02 and 667.90 ktCO_2eq for direct and indirect manure management, respectively. Meanwhile, crop related-GHG emissions accounted for 46,188.59 ktCO_2eq (67.00%). Rice cultivation was the main GHG contributor in Thailand's Agriculture sector, at 33,886.79 ktCO_2eq (49.16%). Agricultural soils emitted 9,547.18 ktCO_2eq (13.85%) with direct and indirect emissions contributing 6,961.78 and 2,585.40 ktCO_2eq, respectively. Field burning of agricultural residues and urea fertilizer contributed similar GHG emissions of 1,688.75 and 1,049.85 ktCO_2eq (2.45 and 1.52%), respectively. The lowest agricultural GHG emission in 2022 was from liming (16.02 ktCO_2eq or 0.02%). Details of 2022 GHG emissions in the agriculture sector by gas type (Figure 2-70 and Table 2-134).

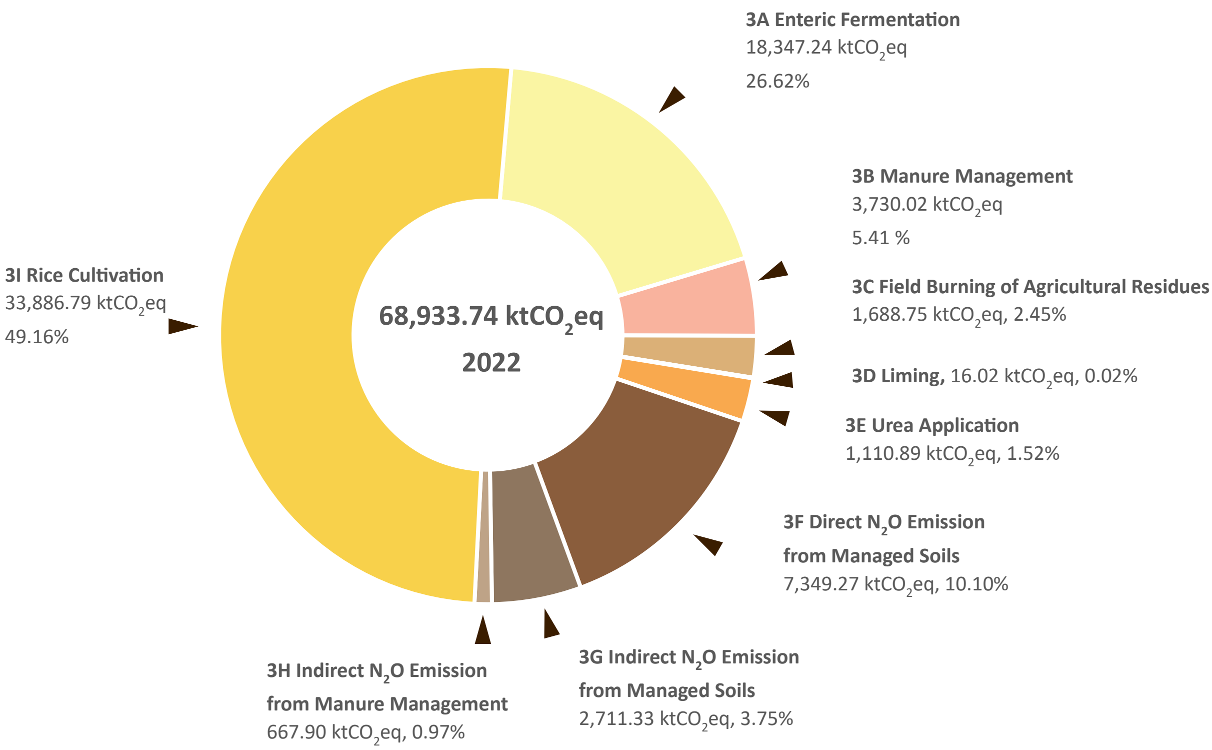


Figure 2-70: GHG emissions in Agriculture sector in 2022

Table 2-132: National greenhouse gas inventory of Thailand in 2020 (Sectors: Agriculture)

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4		N_2O		NO_x	CO	NMVOCs	SO_2	HFCs	PFCs	SF_6	Total
Unit	$ktCO_2eq$	$ktCO_2eq$	kt	$ktCO_2eq$	kt	$ktCO_2eq$	kt	kt	kt	kt	$ktCo_2eq$	$ktCo_2eq$	$ktCo_2eq$	$ktCo_2eq$
3. Agriculture	**1,451.78**		**1,752.45**	**49,068.72**	**43.57**	**11,545.18**	**37.29**	**1,372.24**						**62,065.69**
3A1 Enteric Fermentation			455.50	12,754.08										12,754.08
3A2 Manure Management			88.24	2,470.63	2.04	539.33								3,009.97
3C1b Biomass Burning in Croplands	NA		40.27	1,127.62	1.04	276.69	37.29	1,372.24						1,404.31
3C2 Liming	16.60													16.60
3C3 Urea Fertilization	1,435.18													1,435.18
3C4 Direct N_2O Emission from Managed Soils					28.08	7,441.65								7,441.65
3C5 Indirect N_2O Emission from Managed Soils					10.38	2,749.56								2,749.56
3C6 Indirect N_2O Emission from Manure Management					2.03	537.95								537.95
3C7 Rice Cultivation			1,168.44	32,716.39										32,716.39

Table 2-133: National greenhouse gas inventory of Thailand in 2021 (Sectors: Agriculture)

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4		N_2O		NO_x	CO	NMVOCs	SO_2	HFCs	PFCs	SF_6	Total
Unit	$ktCO_2eq$	$ktCO_2eq$	kt	$ktCO_2eq$	kt	$ktCO_2eq$	kt	kt	kt	kt	$ktCo_2eq$	$ktCo_2eq$	$ktCo_2eq$	$ktCo_2eq$
3. Agriculture	**1,310.55**		**1,897.52**	**53,130.61**	**45.52**	**12,062.15**	**42.94**	**1,580.11**						**66,503.31**
3A1 Enteric Fermentation			548.74	15,364.76										15,364.76
3A2 Manure Management			101.28	2,835.82	2.40	636.26								3,472.08
3C1b Biomass Burning in Croplands	NA		46.37	1,298.44	1.20	318.60	42.94	1,580.11						1,617.03
3C2 Liming	16.37													16.37
3C3 Urea Fertilization	1,294.18													1,294.18
3C4 Direct N_2O Emission from Managed Soils					28.94	7,669.56								7,669.56
3C5 Indirect N_2O Emission from Managed Soils					10.69	2,833.66								2,833.66
3C6 Indirect N_2O Emission from Manure Management					2.28	604.07								604.07
3C7 Rice Cultivation			1,201.13	33,631.60										33,631.60

Table 2-134: National greenhouse gas inventory of Thailand in 2022 (Sectors: Agriculture)

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4		N_2O		NO_x	CO	NMVOCs	SO_2	HFCs	PFCs	SF_6	Total
Unit	$ktCO_2eq$	$ktCO_2eq$	kt	$ktCO_2eq$	kt	$ktCO_2eq$	kt	kt	kt	kt	$ktCo_2eq$	$ktCo_2eq$	$ktCo_2eq$	$ktCo_2eq$
3. Agriculture	**1,065.87**		**2,021.19**	**56,593.38**	**42.55**	**11,274.49**	**44.84**	**1,650.19**						**68,933.74**
3A1 Enteric Fermentation			655.26	18,347.24										18,347.24
3A2 Manure Management			107.26	3,003.33	2.74	726.69								3,730.02
3C1b Biomass Burning in Croplands	NA		48.43	1,356.02	1.26	332.73	44.84	1,650.19						1,688.75
3C2 Liming	16.02													16.02
3C3 Urea Fertilization	1,049.85													1,049.85
3C4 Direct N_2O Emission from Managed Soils					26.27	6,961.78								6,961.78
3C5 Indirect N_2O Emission from Managed Soils					9.76	2,585.40								2,585.40
3C6 Indirect N_2O Emission from Manure Management					2.52	667.90								667.90
3C7 Rice Cultivation			1,210.24	33,886.79										33,886.79

Emissions Trends in the Agriculture Sector

The assessment of GHG emissions from the agriculture sector indicates a slight upward trend. The majority of emissions originate from Rice cultivation (3C7), followed by Enteric fermentation (3A1), and Direct N_2O emissions from agricultural soils (3C4), depending on the year assessed. The increase in GHG emissions from 2020 to 2022 was primarily driven by livestock, particularly the rising populations of nearly all types of livestock examined, such as beef cattle, swine, and chickens. In contrast, rice cultivation showed little change, suggesting that the area dedicated to rice farming remained stable. Consequently, this has led to an upward trend in emissions. This is illustrated in the following tables (Tables 2-135 and 2-136).

Table 2-135: Aggregate GHG emissions in the Agriculture sector for 2000-2022

Year	GHGs (ktCO_2eq or kt)					
	CO_2	CH_4	N_2O	NO_X	CO	Agriculture
2000	1,092.95	42,811.76	8,668.22	31.59	1,162.68	52,572.93
2001	922.08	44,533.62	8,301.83	34.58	1,272.40	53,757.54
2002	1,008.94	42,594.33	8,583.25	34.29	1,261.73	52,186.51
2003	1,188.43	45,475.87	9,313.87	38.27	1,408.47	55,978.17
2004	1,151.48	45,593.36	8,980.68	36.79	1,353.78	55,725.52
2005	925.99	46,548.44	7,938.09	34.95	1,286.08	55,412.52
2006	1,046.27	47,828.09	8,999.87	35.40	1,302.56	57,874.22
2007	1,241.53	49,445.10	10,469.09	37.66	1,385.83	61,155.73
2008	1,187.44	52,193.29	10,022.73	41.83	1,539.47	63,403.46
2009	1,692.37	51,882.94	11,668.03	40.69	1,497.48	65,243.35
2010	1,555.65	51,893.80	11,387.27	43.49	1,600.54	64,836.71
2011	1,564.70	51,825.59	11,901.02	48.58	1,787.90	65,291.30
2012	1,611.97	54,599.59	12,351.11	52.82	1,943.90	68,562.67
2013	1,620.59	49,422.00	11,856.24	50.67	1,864.50	62,898.83
2014	1,593.89	48,449.05	11,688.09	48.72	1,792.84	61,731.03
2015	1,398.12	43,452.63	10,786.25	40.64	1,495.59	55,637.00
2016	1,546.94	42,382.42	11,484.82	36.87	1,356.80	55,414.17
2017	1,838.97	45,658.96	12,847.10	42.02	1,546.50	60,345.03
2018	1,698.97	48,486.76	12,000.86	48.29	1,777.13	62,186.58
2019	1,509.39	47,757.93	11,218.86	40.13	1,476.76	60,486.17
2020	1,451.78	49,068.72	11,545.18	37.29	1,372.24	62,065.69
2021	1,310.55	53,130.61	12,062.15	42.94	1,580.11	66,503.31
2022	1,065.87	56,593.38	11,274.49	44.84	1,650.19	68,933.74

Table 2-136: GHG emissions by each subcategory in Agriculture sector for 2000-2022

Year	Source category									
	3A1 Enteric Fermentation	3A2 Manure Management	3C1b Biomass Burning in Croplands	3C2 Liming	3C3 Urea Fertilization	3C4 Direct N_2O Emission from Managed Soils	3C5 Indirect N_2O Emission from Managed Soils	3C6 Indirect N_2O Emission from Manure Management	3C7 Rice Cultivation	Agriculture
2000	10,512.53	2,019.46	1,189.85	0.00	1,092.95	5,589.48	2,116.04	312.97	29,739.65	52,572.93
2001	10,889.76	2,077.22	1,302.14	0.00	922.08	5,255.09	2,029.40	336.13	30,945.71	53,757.54
2002	11,266.04	2,134.60	1,291.22	0.00	1,008.94	5,443.35	2,092.35	359.23	28,590.79	52,186.51
2003	11,645.95	2,156.17	1,441.38	0.00	1,188.43	5,984.93	2,273.13	344.83	30,943.34	55,978.17
2004	12,024.28	2,177.21	1,385.41	0.00	1,151.48	5,759.93	2,197.43	330.38	30,699.40	55,725.52
2005	12,986.71	2,348.38	1,316.14	0.00	925.99	4,938.45	1,934.91	358.87	30,603.06	55,412.52
2006	13,927.61	2,516.40	1,333.00	0.00	1,046.27	5,704.81	2,173.20	386.86	30,786.08	57,874.22
2007	14,707.54	2,679.79	1,418.22	0.00	1,241.53	6,757.50	2,517.43	418.49	31,415.23	61,155.73
2008	15,457.90	2,838.52	1,575.45	0.00	1,187.44	6,334.44	2,409.44	449.43	33,150.83	63,403.46
2009	15,282.54	2,906.52	1,532.47	0.00	1,692.37	7,541.97	2,804.81	482.04	33,000.62	65,243.35
2010	11,497.91	2,386.97	1,637.94	0.00	1,555.65	7,412.63	2,831.92	392.44	37,121.24	64,836.71
2011	11,968.12	2,585.66	1,829.69	33.59	1,531.11	7,698.67	2,946.68	437.85	36,259.95	65,291.30
2012	11,838.35	2,699.63	1,989.33	32.60	1,579.37	7,943.17	3,060.56	482.00	38,937.65	68,562.67
2013	8,917.36	2,205.84	1,908.08	29.08	1,591.51	7,711.74	2,960.55	424.14	37,150.53	62,898.83
2014	8,619.18	2,150.85	1,834.74	30.22	1,563.66	7,632.95	2,898.19	417.82	36,583.42	61,731.03
2015	8,935.64	2,247.01	1,530.54	29.92	1,368.20	7,047.09	2,588.36	450.57	31,439.67	55,637.00
2016	9,495.24	2,356.52	1,388.51	29.92	1,517.01	7,597.93	2,734.05	458.72	29,836.26	55,414.17
2017	10,054.52	2,465.91	1,582.64	29.92	1,809.05	8,512.50	3,113.54	466.85	32,310.10	60,345.03
2018	11,258.51	2,666.80	1,818.66	27.59	1,671.38	7,749.92	2,898.40	506.23	33,589.08	62,186.58
2019	12,057.69	2,842.47	1,511.27	25.48	1,483.90	7,167.87	2,711.99	524.97	32,160.52	60,486.17
2020	12,754.08	3,009.97	1,404.31	16.60	1,435.18	7,441.65	2,749.56	537.95	32,716.39	62,065.69
2021	15,364.76	3,472.08	1,617.03	16.37	1,294.18	7,669.56	2,833.66	604.07	33,631.60	66,503.31
2022	18,347.24	3,730.02	1,688.75	16.02	1,049.85	6,961.78	2,585.40	667.90	33,886.79	68,933.74

Recalculations and Improvements in the Agriculture Sector

Recalculations

The inventories submitted in the Fourth Biennial Update Report (BUR4) were calculated using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories with GWP from AR4, e.g., GWP_{CH4} of 25 and GWP_{N2O} of 298. For the current report, the 2006 IPCC Guidelines were also adopted to extend the GHG emissions in the agriculture sector and GWP from AR5, e.g., GWP_{CH4} of 28 and GWP_{N2O} of 265, was used. Recalculation was performed for the agriculture sector for 2000-2022, and Table 2-137 shows the total GHG emissions in Thailand's agriculture sector. The comparison of GWP values between AR4 and AR5 reveals significant differences across various emission sectors. Utilizing AR5 results in a 12% increase in CH_4 emissions and an 11% decrease in N_2O emissions. Overall, GHG emissions from the agricultural sector have risen by 6-8% (Tables 2-138 and 2-139).

Improvement

Activity data, emission factors, and relevant constants or factors should be updated for various subcategories within the agriculture sector. The following areas should be prioritized for improvement:

- The percentage of manure management (MS) for certain livestock, particularly swine, needs to be updated.
- Develop a technique and reporting system for agricultural areas affected by burning, using direct measurement data such as satellite imagery to quantify cropland areas, including estimates of biomass fuel mass (MB), where technically feasible.
- CH_4 emission factors (EFs) for rice cultivation should be updated to reflect the increased availability of EFs and scaling factors for water management practices (SF_w), such as alternative wetting and drying (AWD).

Table 2-137: GHG emissions in BTR1 in Agriculture sector for 2000-2022

Year	Enteric CH_4 emission ($ktCO_2eq/yr$)	Manure CH_4 emission ($ktCO_2eq/yr$)	Manure N_2O emission ($ktCO_2eq/yr$)	GHG emissions from field burning ($ktCO_2eq/yr$)	CO_2 emissions from liming ($ktCO_2/yr$)	CO_2 emissions from urea fertilization ($ktCO_2/yr$)	Direct agricultural N_2O emission ($ktCO_2eq/yr$)	Indirect agricultural N_2O emission ($ktCO_2eq/yr$)	Indirect agricultural N_2O emission (manure) ($ktCO_2eq/yr$)	Rice CH_4 emission ($ktCO_2eq/yr$)	Sum ($ktCO_2eq/yr$)
	BTR1: 2006 IPCC GLs (GWP of AR5, CH_4 =28 and N_2O = 265)										
2000	10,512.53	1,604.17	415.29	1,189.85	-	1,092.95	5,589.48	2,116.04	312.97	29,739.65	**52,572.93**
2001	10,889.76	1,652.57	424.65	1,302.14	-	922.08	5,255.09	2,029.40	336.13	30,945.71	**53,757.54**
2002	11,266.04	1,700.69	433.91	1,291.22	-	1,008.94	5,443.35	2,092.35	359.23	28,590.79	**52,186.51**
2003	11,645.95	1,729.18	426.99	1,441.38	-	1,188.43	5,984.93	2,273.13	344.83	30,943.34	**55,978.17**
2004	12,024.28	1,757.24	419.97	1,385.41	-	1,151.48	5,759.93	2,197.43	330.38	30,699.40	**55,725.52**
2005	12,986.71	1,901.84	446.54	1,316.14	-	925.99	4,938.45	1,934.91	358.87	30,603.06	**55,412.52**
2006	13,927.61	2,044.04	472.36	1,333.00	-	1,046.27	5,704.81	2,173.20	386.86	30,786.08	**57,874.22**
2007	14,707.54	2,183.53	496.25	1,418.22	-	1,241.53	6,757.50	2,517.43	418.49	31,415.23	**61,155.73**
2008	15,457.90	2,319.51	519.01	1,575.45	-	1,187.44	6,334.44	2,409.44	449.43	33,150.83	**63,403.46**
2009	15,282.54	2,369.24	537.27	1,532.47	-	1,692.37	7,541.97	2,804.81	482.04	33,000.62	**65,243.35**
2010	11,497.91	1,959.42	427.55	1,637.94	-	1,555.65	7,412.63	2,831.92	392.44	37,121.24	**64,836.71**
2011	11,968.12	2,128.33	457.32	1,829.69	33.59	1,531.11	7,698.67	2,946.68	437.85	36,259.95	**65,291.30**
2012	11,838.35	2,226.20	473.43	1,989.33	32.60	1,579.37	7,943.17	3,060.56	482.00	38,937.65	**68,562.67**
2013	8,917.36	1,821.96	383.87	1,908.08	29.08	1,591.51	7,711.74	2,960.55	424.14	37,150.53	**62,898.83**
2014	8,619.18	1,773.21	377.64	1,834.74	30.22	1,563.66	7,632.95	2,898.19	417.82	36,583.42	**61,731.03**
2015	8,935.64	1,848.34	398.67	1,530.54	29.92	1,368.20	7,047.09	2,588.36	450.57	31,439.67	**55,637.00**
2016	9,495.24	1,935.98	420.55	1,388.51	29.92	1,517.01	7,597.93	2,734.05	458.72	29,836.26	**55,414.17**
2017	10,054.52	2,023.51	442.40	1,582.64	29.92	1,809.05	8,512.50	3,113.54	466.85	32,310.10	**60,345.03**
2018	11,258.51	2,178.83	487.98	1,818.66	27.59	1,671.38	7,749.92	2,898.40	506.23	33,589.08	**62,186.58**
2019	12,057.69	2,326.20	516.27	1,511.27	25.48	1,483.90	7,167.87	2,711.99	524.97	32,160.52	**60,486.17**
2020	12,754.08	2,470.63	539.33	1,404.31	16.60	1,435.18	7,441.65	2,749.56	537.95	32,716.39	**62,065.69**
2021	15,364.76	2,835.82	636.26	1,617.03	16.37	1,294.18	7,669.56	2,833.66	604.07	33,631.60	**66,503.31**
2022	18,347.24	3,003.33	726.69	1,688.75	16.02	1,049.85	6,961.78	2,585.40	667.90	33,886.79	**68,933.74**

Table 2-138: GHG emissions in BUR4 in Agriculture sector for 2000-2022

Year	Enteric CH_4 emission ($ktCO_2eq/yr$)	Manure CH_4 emission ($ktCO_2eq/yr$)	Manure N_2O emission ($ktCO_2eq/yr$)	GHG emissions from field burning ($ktCO_2eq/yr$)	CO_2 emissions from liming ($ktCO_2/yr$)	CO_2 emissions from urea fertilization ($ktCO_2/yr$)	Direct agricultural N_2O emission ($ktCO_2eq/yr$)	Indirect agricultural N_2O emission ($ktCO_2eq/yr$)	Indirect agricultural N_2O emission (manure) ($ktCO_2eq/yr$)	Rice CH_4 emission ($ktCO_2eq/yr$)	Sum ($ktCO_2eq/yr$)
	BUR4: 2006 IPCC GLs (GWP of AR4, CH_4 =25 and N_2O = 298)										
2000	9,386.19	1,432.29	467.01	1,116.68	-	1,092.95	6,285.53	2,379.55	351.94	26,553.26	**49,065.40**
2001	9,723.00	1,475.51	477.53	1,222.06	-	922.08	5,909.50	2,282.12	377.99	27,630.10	**50,019.89**
2002	10,058.96	1,518.47	487.94	1,211.81	-	1,008.94	6,121.20	2,352.91	403.97	25,527.49	**48,691.69**
2003	10,398.17	1,543.91	480.17	1,352.74	-	1,188.43	6,730.22	2,556.20	387.77	27,627.98	**52,265.60**
2004	10,735.96	1,568.96	472.27	1,300.22	-	1,151.48	6,477.20	2,471.08	371.52	27,410.18	**51,958.87**
2005	11,595.28	1,698.07	502.15	1,235.20	-	925.99	5,553.43	2,175.86	403.56	27,324.16	**51,413.70**
2006	12,435.36	1,825.03	531.18	1,251.02	-	1,046.27	6,415.22	2,443.83	435.03	27,487.57	**53,870.52**
2007	13,131.74	1,949.58	558.05	1,331.00	-	1,241.53	7,599.00	2,830.92	470.6	28,049.31	**57,161.74**
2008	13,801.70	2,070.99	583.64	1,478.56	-	1,187.44	7,123.26	2,709.48	505.4	29,598.96	**59,059.43**
2009	13,645.12	2,115.40	604.18	1,438.23	-	1,692.37	8,481.16	3,154.09	542.07	29,464.84	**61,137.46**
2010	10,265.99	1,749.48	480.79	1,537.21	-	1,555.65	8,335.72	3,184.58	441.31	33,143.96	**60,694.70**
2011	10,685.82	1,900.30	514.27	1,717.16	33.59	1,531.11	8,657.37	3,313.62	492.38	32,374.95	**61,220.57**
2012	10,569.96	1,987.68	532.39	1,866.99	32.6	1,579.37	8,932.32	3,441.69	542.02	34,765.76	**64,250.78**
2013	7,961.93	1,626.75	431.68	1,790.73	29.08	1,591.51	8,672.07	3,329.22	476.95	33,170.12	**59,080.05**
2014	7,695.69	1,583.22	424.67	1,721.91	30.22	1,563.66	8,583.46	3,259.10	469.85	32,663.77	**57,995.56**
2015	7,978.25	1,650.31	448.31	1,436.42	29.92	1,368.20	7,924.65	2,910.68	506.68	28,071.13	**52,324.55**
2016	8,477.89	1,728.55	472.92	1,303.12	29.92	1,517.01	8,544.09	3,074.52	515.84	26,639.52	**52,303.38**
2017	8,977.25	1,806.71	497.49	1,485.31	29.92	1,809.05	9,572.54	3,501.27	524.98	28,848.31	**57,052.83**
2018	10,052.24	1,945.38	548.74	1,706.82	27.59	1,671.38	8,715.01	3,259.34	569.27	29,990.25	**58,486.02**
2019	10,765.80	2,076.97	580.56	1,418.33	25.48	1,483.90	8,060.47	3,049.71	590.34	28,714.75	**56,766.32**
2020	11,387.57	2,205.92	606.5	1,317.95	16.6	1,435.18	8,368.35	3,091.96	604.94	29,211.06	**58,246.03**
2021	13,718.53	2,531.98	715.49	1,517.59	16.37	1,294.18	8,624.64	3,186.53	679.29	30,028.21	**62,312.82**
2022	16,381.46	2,681.54	817.18	1,584.90	16.02	1,049.85	7,828.72	2,907.36	751.07	30,256.06	**64,274.16**

Table 2-139: Comparison of GHG emissions between BTR1 and BUR4 in Agriculture sector for 2000-2022.

Year	Enteric CH_4 emission ($ktCO_2eq/yr$)	Manure CH_4 emission ($ktCO_2eq/yr$)	Manure N_2O emission ($ktCO_2eq/yr$)	GHG emissions from field burning ($ktCO_2eq/yr$)	CO_2 emissions from liming ($ktCO_2/yr$)	CO_2 emissions from urea fertilization ($ktCO_2/yr$)	Direct agricultural N_2O emission ($ktCO_2eq/yr$)	Indirect agricultural N_2O emission ($ktCO_2eq/yr$)	Indirect agricultural N_2O emission (manure) ($ktCO_2eq/yr$)	Rice CH_4 emission ($ktCO_2eq/yr$)	Sum ($ktCO_2eq/yr$)
	BTR1/BUR4										
2000	1.12	1.12	0.89	1.07	-	1.00	0.89	0.89	0.89	1.12	**1.07**
2001	1.12	1.12	0.89	1.07	-	1.00	0.89	0.89	0.89	1.12	**1.07**
2002	1.12	1.12	0.89	1.07	-	1.00	0.89	0.89	0.89	1.12	**1.07**
2003	1.12	1.12	0.89	1.07	-	1.00	0.89	0.89	0.89	1.12	**1.07**
2004	1.12	1.12	0.89	1.07	-	1.00	0.89	0.89	0.89	1.12	**1.07**
2005	1.12	1.12	0.89	1.07	-	1.00	0.89	0.89	0.89	1.12	**1.08**
2006	1.12	1.12	0.89	1.07	-	1.00	0.89	0.89	0.89	1.12	**1.07**
2007	1.12	1.12	0.89	1.07	-	1.00	0.89	0.89	0.89	1.12	**1.07**
2008	1.12	1.12	0.89	1.07	-	1.00	0.89	0.89	0.89	1.12	**1.07**
2009	1.12	1.12	0.89	1.07	-	1.00	0.89	0.89	0.89	1.12	**1.07**
2010	1.12	1.12	0.89	1.07	-	1.00	0.89	0.89	0.89	1.12	**1.07**
2011	1.12	1.12	0.89	1.07	1.00	1.00	0.89	0.89	0.89	1.12	**1.07**
2012	1.12	1.12	0.89	1.07	1.00	1.00	0.89	0.89	0.89	1.12	**1.07**
2013	1.12	1.12	0.89	1.07	1.00	1.00	0.89	0.89	0.89	1.12	**1.06**
2014	1.12	1.12	0.89	1.07	1.00	1.00	0.89	0.89	0.89	1.12	**1.06**
2015	1.12	1.12	0.89	1.07	1.00	1.00	0.89	0.89	0.89	1.12	**1.06**
2016	1.12	1.12	0.89	1.07	1.00	1.00	0.89	0.89	0.89	1.12	**1.06**
2017	1.12	1.12	0.89	1.07	1.00	1.00	0.89	0.89	0.89	1.12	**1.06**
2018	1.12	1.12	0.89	1.07	1.00	1.00	0.89	0.89	0.89	1.12	**1.06**
2019	1.12	1.12	0.89	1.07	1.00	1.00	0.89	0.89	0.89	1.12	**1.07**
2020	1.12	1.12	0.89	1.07	1.00	1.00	0.89	0.89	0.89	1.12	**1.07**
2021	1.12	1.12	0.89	1.07	1.00	1.00	0.89	0.89	0.89	1.12	**1.07**
2022	1.12	1.12	0.89	1.07	1.00	1.00	0.89	0.89	0.89	1.12	**1.07**

Recalculation for BTR1 using Tier 1 approach

When comparing the assessments based on Thailand's GHG inventory (Tier 1 and Tier 2) with the Tier 1 model in the agriculture sector, it was observed that the total GHG emissions are relatively similar, with a variation range of 97-102%. Emissions from crop cultivation activities, such as rice farming and fertilizer application, show minimal differences between the two assessment methods. Specifically, for rice cultivation, the CH_4 emission factors—both the country-specific EFs and the default EFs by the 2006 IPCC GLs—are closely aligned.

In contrast, emissions from the livestock sector exhibit significant discrepancies, particularly regarding enteric fermentation and manure management. These differences arise from the use of country-specific animal characteristics and manure management systems in assessing emissions, in particular of ruminant animals and swine, which diverge considerably from the IPCC recommendations based on other Asian countries (Tables 2-140 and 2-141).

Table 2-140: GHG emissions in BTR1 using Tier 1 approach in Agriculture sector for 2000-2022

Year	Enteric CH_4 emission ($ktCO_2eq/yr$)	Manure CH_4 emission ($ktCO_2eq/yr$)	Manure N_2O emission ($ktCO_2eq/yr$)	GHG emissions from field burning ($ktCO_2eq/yr$)	CO_2 emissions from liming ($ktCO_2/yr$)	CO_2 emissions from urea fertilization ($ktCO_2/yr$)	Direct agricultural N_2O emission ($ktCO_2eq/yr$)	Indirect agricultural N_2O emission ($ktCO_2eq/yr$)	Indirect agricultural N_2O emission (manure) ($ktCO_2eq/yr$)	Rice CH_4 emission ($ktCO_2eq/yr$)	Sum ($ktCO_2eq/yr$)
	BTR1: 2006 IPCC GLs (GWP of AR5, CH_4 = 28 and N_2O = 265) using Tier 1										
2000	9,569.19	1,552.50	1,129.45	1,179.78	-	1,092.95	5,641.87	2,090.26	180.93	30,099.93	**52,536.87**
2001	9,842.11	1,533.68	1,153.45	1,290.59	-	922.08	5,346.91	2,009.22	185.35	31,519.77	**53,803.18**
2002	10,114.11	1,514.11	1,177.32	1,291.22	-	1,008.94	5,581.82	2,080.23	189.75	29,579.77	**52,537.26**
2003	10,573.43	1,481.36	1,220.25	1,441.38	-	1,188.43	6,173.69	2,279.57	196.96	31,808.18	**56,363.26**
2004	11,031.02	1,446.19	1,262.71	1,385.41	-	1,151.48	5,998.80	2,222.36	204.08	31,735.85	**56,437.90**
2005	11,832.87	1,530.12	1,374.60	1,316.14	-	925.99	5,196.91	1,963.68	221.03	31,468.90	**55,830.23**
2006	12,616.94	1,611.62	1,484.30	1,333.00	-	1,046.27	5,982.77	2,205.76	237.62	31,992.07	**58,510.34**
2007	13,312.66	1,703.14	1,566.50	1,418.22	-	1,241.53	7,071.87	2,553.12	251.12	32,745.27	**61,863.44**
2008	13,983.16	1,790.95	1,646.21	1,575.45	-	1,187.44	6,685.18	2,448.24	264.13	35,247.42	**64,828.19**
2009	13,547.13	1,912.91	1,613.03	1,532.47	-	1,692.37	7,816.35	2,813.39	259.72	34,840.69	**66,028.06**
2010	10,523.38	1,815.81	1,252.47	1,637.94	-	1,555.65	7,639.74	2,828.92	207.00	38,714.19	**66,175.11**
2011	10,912.82	2,045.69	1,321.67	1,829.69	33.59	1,531.11	7,929.80	2,932.07	218.76	38,307.80	**67,063.00**
2012	10,748.41	2,257.79	1,329.05	1,989.33	32.60	1,579.37	8,162.66	3,028.16	220.75	41,228.71	**70,576.84**
2013	8,051.96	1,948.48	1,022.74	1,908.08	29.08	1,591.51	7,887.51	2,919.07	172.41	39,242.20	**64,773.03**
2014	7,788.42	1,940.94	996.66	1,834.74	30.22	1,563.66	7,800.62	2,856.22	168.52	38,349.04	**63,329.05**
2015	7,980.80	2,019.77	1,022.78	1,530.54	29.92	1,368.20	7,219.11	2,539.36	172.79	31,862.29	**55,745.56**
2016	8,444.92	2,075.96	1,069.45	1,388.51	29.92	1,517.01	7,750.81	2,679.91	181.21	29,537.02	**54,674.71**
2017	8,908.72	2,131.88	1,116.06	1,582.64	29.92	1,809.05	8,646.21	3,054.25	189.61	33,309.72	**60,778.08**
2018	9,958.49	2,248.35	1,232.23	1,818.66	27.59	1,671.38	7,910.25	2,841.75	208.39	34,966.80	**62,883.89**
2019	10,668.80	2,385.14	1,320.22	1,511.27	25.48	1,483.90	7,330.36	2,653.77	223.17	33,362.27	**60,964.39**
2020	11,251.18	2,541.48	1,400.17	1,404.31	16.60	1,435.18	7,596.24	2,687.67	236.48	32,444.93	**61,014.25**
2021	13,496.63	2,792.02	1,644.07	1,617.03	16.37	1,294.18	7,827.22	2,767.33	276.68	33,673.31	**65,404.85**
2022	15,948.73	2,574.93	1,859.53	1,688.75	16.02	1,049.85	7,199.71	2,544.14	309.22	34,417.35	**67,608.23**

Table 2-141: Comparison of GHG emissions between BTR1 using Thailand's GHG inventory (T1 and T2) and T1 in Agriculture sector for 2000-2022

Year	Enteric CH_4 emission ($ktCO_2eq/yr$)	Manure CH_4 emission ($ktCO_2eq/yr$)	Manure N_2O emission ($ktCO_2eq/yr$)	GHG emissions from field burning ($ktCO_2eq/yr$)	CO_2 emissions from liming ($ktCO_2/yr$)	CO_2 emissions from urea fertilization ($ktCO_2/yr$)	Direct agricultural N_2O emission ($ktCO_2eq/yr$)	Indirect agricultural N_2O emission ($ktCO_2eq/yr$)	Indirect agricultural N_2O emission (manure) ($ktCO_2eq/yr$)	Rice CH_4 emission ($ktCO_2eq/yr$)	Sum ($ktCO_2eq/yr$)
	Thailand Inventory (T1 and T2) / T1										
2000	1.10	1.03	0.37	1.01	-	1.00	0.99	1.01	1.73	0.99	**1.00**
2001	1.11	1.08	0.37	1.01	-	1.00	0.98	1.01	1.81	0.98	**1.00**
2002	1.11	1.12	0.37	1.00	-	1.00	0.98	1.01	1.89	0.97	**0.99**
2003	1.10	1.17	0.35	1.00	-	1.00	0.97	1.00	1.75	0.97	**0.99**
2004	1.09	1.22	0.33	1.00	-	1.00	0.96	0.99	1.62	0.97	**0.99**
2005	1.10	1.24	0.32	1.00	-	1.00	0.95	0.99	1.62	0.97	**0.99**
2006	1.10	1.27	0.32	1.00	-	1.00	0.95	0.99	1.63	0.96	**0.99**
2007	1.10	1.28	0.32	1.00	-	1.00	0.96	0.99	1.67	0.96	**0.99**
2008	1.11	1.30	0.32	1.00	-	1.00	0.95	0.98	1.70	0.94	**0.98**
2009	1.13	1.24	0.33	1.00	-	1.00	0.96	1.00	1.86	0.95	**0.99**
2010	1.09	1.08	0.34	1.00	-	1.00	0.97	1.00	1.90	0.96	**0.98**
2011	1.10	1.04	0.35	1.00	1.00	1.00	0.97	1.00	2.00	0.95	**0.97**
2012	1.10	0.99	0.36	1.00	1.00	1.00	0.97	1.01	2.18	0.94	**0.97**
2013	1.11	0.94	0.38	1.00	1.00	1.00	0.98	1.01	2.46	0.95	**0.97**
2014	1.11	0.91	0.38	1.00	1.00	1.00	0.98	1.01	2.48	0.95	**0.97**
2015	1.12	0.92	0.39	1.00	1.00	1.00	0.98	1.02	2.61	0.99	**1.00**
2016	1.12	0.93	0.39	1.00	1.00	1.00	0.98	1.02	2.53	1.01	**1.01**
2017	1.13	0.95	0.40	1.00	1.00	1.00	0.98	1.02	2.46	0.97	**0.99**
2018	1.13	0.97	0.40	1.00	1.00	1.00	0.98	1.02	2.43	0.96	**0.99**
2019	1.13	0.98	0.39	1.00	1.00	1.00	0.98	1.02	2.35	0.96	**0.99**
2020	1.13	0.97	0.39	1.00	1.00	1.00	0.98	1.02	2.27	1.01	**1.02**
2021	1.14	1.02	0.39	1.00	1.00	1.00	0.98	1.02	2.18	1.00	**1.02**
2022	1.15	1.17	0.39	1.00	1.00	1.00	0.97	1.02	2.16	0.98	**1.02**

Uncertainties

To perform uncertainty analysis (UA) for Thailand's agriculture sector, the UA methodology according to the 2006 IPCC GLs was adopted. The uncertainty of activity data and emission factors primarily were adopted from the suggested values or ranges of Tier 1 and Tier 2 approaches. Level and trend uncertainty were analyzed. The uncertainty analysis was performed for each subcategory and the whole agriculture sector. The UA results for the years 2020, 2021 and 2022 indicated total uncertainty values of ±28.64, ±27.20 and ±25.76%, respectively. For trend analysis, the UA results were ±6.45% for 2020, ±8.16% for 2021 and ±11.66% for 2022.

For the agriculture sector, overall uncertainty in 2000-2022 was 25.76-31.32% of Thailand's national GHG inventory. Trend uncertainty was 4.33-11.66% during 2000-2022. Uncertainties were variated in a narrow range, due to a consistency in GHG emission composition in this sector (Tables 2-142, 2-143, 2-144 and 2-145).

Table 2-142: GHG emissions and uncertainty analysis in the Agriculture sector in 2020

IPCC Category	Greenhouse Gas	Emissions or removals in 2000	Emissions or removals in 2020	Activity Data (AD) Uncertainty	Emission Factor (EF) Uncertainty	Combined Uncertainty	Combined Uncertainty as % of Emissions in 2001	Type A Sensitivity	Type B Sensitivity	Uncertainty in Trend in Total Emissions due to EF	Uncertainty in Trend in Total Emissions due to AD	Combined Uncertainty in Total Emissions
3 Agriculture, Forestry and Other Land Use		$ktCO_2eq$	$ktCO_2eq$	%	%	%	%			%	%	%
3A Livestock												
3A1 Enteric fermentation	CH_4											
Dairy cattle	CH_4	520.33	1,232.58	20.00%	20.00%	28.28%	0.00%	0.01176	0.02345	0.24%	0.66%	0.00%
Other cattle (Beef cattle)	CH_4	6,447.75	8,511.30	20.00%	20.00%	28.28%	0.15%	0.01709	0.16190	0.34%	4.58%	0.21%
Buffalo	CH_4	3,193.07	2,350.17	20.00%	20.00%	28.28%	0.01%	0.02698	0.04470	0.54%	1.26%	0.02%
Sheep	CH_4	5.22	11.65	20.00%	50.00%	53.85%	0.00%	0.00010	0.00022	0.01%	0.01%	0.00%
Goats	CH_4	20.19	134.80	20.00%	50.00%	53.85%	0.00%	0.00211	0.00256	0.11%	0.07%	0.00%
Swine	CH_4	325.96	513.59	20.00%	50.00%	53.85%	0.00%	0.00245	0.00977	0.12%	0.28%	0.00%
3A2 Manure management (CH_4)	CH_4											
Dairy cattle	CH_4	120.87	286.32	20.00%	20.00%	28.28%	0.00%	0.00273	0.00545	0.05%	0.15%	0.00%
Other cattle (Beef cattle)	CH_4	731.83	973.47	20.00%	20.00%	28.28%	0.00%	0.00208	0.01852	0.04%	0.52%	0.00%
Buffalo	CH_4	123.07	90.58	20.00%	20.00%	28.28%	0.00%	0.00104	0.00172	0.02%	0.05%	0.00%
Sheep	CH_4	0.21	0.47	20.00%	20.00%	28.28%	0.00%	0.00000	0.00001	0.00%	0.00%	0.00%
Goats	CH_4	0.89	5.93	20.00%	30.00%	36.06%	0.00%	0.00009	0.00011	0.00%	0.00%	0.00%
Swine	CH_4	505.65	843.07	20.00%	30.00%	36.06%	0.00%	0.00468	0.01604	0.14%	0.45%	0.00%
Poultry	CH_4	121.65	270.79	20.00%	30.00%	36.06%	0.00%	0.00242	0.00515	0.07%	0.15%	0.00%
3A2 Manure management (Direct N_2O emission)	N_2O											
Dairy cattle	N_2O	29.41	68.29	53.85%	111.80%	124.09%	0.00%	0.00064	0.00130	0.07%	0.10%	0.00%
Other cattle (Beef cattle)	N_2O	140.66	191.39	53.85%	111.80%	124.09%	0.00%	0.00048	0.00364	0.05%	0.28%	0.00%
Buffalo	N_2O	180.64	132.62	53.85%	111.80%	124.09%	0.00%	0.00153	0.00252	0.17%	0.19%	0.00%
Sheep	N_2O	0.76	1.70	53.85%	111.80%	124.09%	0.00%	0.00002	0.00003	0.00%	0.00%	0.00%
Goats	N_2O	3.69	24.66	53.85%	111.80%	124.09%	0.00%	0.00039	0.00047	0.04%	0.04%	0.00%
Swine	N_2O	14.84	24.53	53.85%	111.80%	124.09%	0.00%	0.00013	0.00047	0.01%	0.04%	0.00%
Poultry	N_2O	45.28	96.14	53.85%	111.80%	124.09%	0.00%	0.00081	0.00183	0.09%	0.14%	0.00%
3C Aggregate sources and non-CO_2 emissions sources on land												
3C1b Emissions from biomass burning	CH_4, N_2O											
3C1b Biomass burning in croplands (CH_4)	CH_4	955.42	1,127.62	0.00%	100.00%	100.00%	0.03%	0.00001	0.02145	0.00%	0.00%	0.00%
3C1b Biomass burning in croplands (N_2O)	N_2O	234.43	276.69	0.00%	100.00%	100.00%	0.00%	0.00000	0.00526	0.00%	0.00%	0.00%
3C2 Liming	CO_2	-	16.60	0.00%	50.00%	50.00%	0.00%	0.00032	0.00032	0.02%	0.00%	0.00%
3C3 Urea application	CO_2	1,092.95	1,435.18	0.00%	50.00%	50.00%	0.01%	0.00276	0.02730	0.14%	0.00%	0.00%
3C4 Direct N_2O emissions from managed soils	N_2O											
(1) Synthetic fertilizers	N_2O											
Synthetic fertilizers - EF_1	N_2O	2,264.68	3,101.51	0.00%	200.00%	200.00%	1.00%	0.00814	0.05899	1.63%	0.00%	0.03%
Synthetic fertilizers - EF_{1FR}	N_2O	536.16	573.12	0.00%	100.00%	100.00%	0.01%	0.00114	0.01090	0.11%	0.00%	0.00%
(2) Manure - EF_1	N_2O	649.61	1,134.67	0.00%	269.13%	269.13%	0.24%	0.00699	0.02158	1.88%	0.00%	0.04%
(3) Crop residues	N_2O											
Crop residues - EF_1	N_2O	820.57	1,097.19	0.00%	203.38%	203.38%	0.13%	0.00244	0.02087	0.50%	0.00%	0.00%
Crop residues - EF_{1FR}	N_2O	107.68	117.05	0.00%	106.60%	106.60%	0.00%	0.00019	0.00223	0.02%	0.00%	0.00%

Table 2-142: GHG emissions and uncertainty analysis in the Agriculture sector in 2020 (Cont'd)

IPCC Category	Greenhouse Gas	Emissions or removals in 2000	Emissions or removals in 2022	Activity Data (AD) Uncertainty	Emission Factor (EF) Uncertainty	Combined Uncertainty	Combined Uncertainty as % of Emissions in 2001	Type A Sensitivity	Type B Sensitivity	Uncertainty in Trend in Total Emissions due to EF	Uncertainty in Trend in Total Emissions due to AD	Combined Uncertainty in Trend in Total Emissions
3 Agriculture, Forestry and Other Land Use		$ktCO_2eq$	$ktCO_2eq$	%	%	%	%			%	%	%
(4) Organic soils	N_2O	-	-	0.00%	200.00%	200.00%	0.00%	0.00000	0.00000	0.00%	0.00%	0.00%
(5) Manure (pasture)	N_2O	1,210.78	1,418.12	53.85%	206.16%	213.08%	0.24%	0.00021	0.02697	0.04%	2.05%	0.04%
3C5 Indirect N_2O emissions from managed soils	N_2O											
Volatilisation (EF_4)												
(1) Synthetic fertilizers	N_2O	405.19	501.19	0.00%	447.21%	447.21%	0.13%	0.00043	0.00953	0.19%	0.00%	0.00%
(2) Manure	N_2O	251.20	369.90	0.00%	463.60%	463.60%	0.08%	0.00140	0.00704	0.65%	0.00%	0.00%
Leaching (EF_5)												
(1) Synthetic fertilizers	N_2O	911.68	1,127.68	0.00%	286.67%	286.67%	0.27%	0.00098	0.02145	0.28%	0.00%	0.00%
(2) Manure	N_2O	282.60	416.14	0.00%	338.54%	338.54%	0.05%	0.00157	0.00792	0.53%	0.00%	0.00%
(3) Crop residues	N_2O	265.39	334.65	0.00%	289.03%	289.03%	0.02%	0.00041	0.00637	0.12%	0.00%	0.00%
3C6 Indirect N_2O emissions from manure management	N_2O	312.97	537.95	53.85%	423.25%	426.66%	0.14%	0.00320	0.01023	1.36%	0.78%	0.02%
3C7 Rice cultivations	CH_4											
Major rice	CH_4											
(1) SF_w-irrigated	CH_4	9,300.50	10,460.55	0.00%	78.68%	78.68%	1.76%	0.00986	0.19897	0.78%	0.00%	0.01%
(2) SF_w-rainfed (regular)	CH_4	4,564.45	4,591.87	0.00%	78.26%	78.26%	0.34%	0.01514	0.08734	1.19%	0.00%	0.01%
(3) SF_w-rainfed (drought prone)	CH_4	11,879.54	13,482.49	0.00%	83.89%	83.89%	3.32%	0.01029	0.25645	0.86%	0.00%	0.01%
(4) SF_w-rainfed (deep water)	CH_4	157.74	161.84	0.00%	122.89%	122.89%	0.00%	0.00046	0.00308	0.06%	0.00%	0.00%
Second rice (SF_w-irrigated)	CH_4	3,837.42	4,019.64	0.00%	78.68%	78.68%	0.26%	0.00971	0.07646	0.76%	0.00%	0.01%
Total		**52,572.93**	**62,065.69**				**8.21%**					**0.42%**
						Percentage uncertainty in total inventory =	**28.64%**				**Trend uncertainty =**	**6.45%**

Note: For Type A sensitivity, use the equation: ABS[((0.01xD + TotalD)/(0.01xC + TotalC) - 1) x 100 - (TotalD/TotalC -1) x 100].

Table 2-143: GHG emissions and uncertainty analysis in the Agriculture sector in 2021

IPCC Category	Greenhouse Gas	Emissions or removals in 2000	Emissions or removals in 2021	Activity Data (AD) Uncertainty	Emission Factor (EF) Uncertainty	Combined Uncertainty	Combined Uncertainty as % of Emissions in 2001	Type A Sensitivity	Type B Sensitivity	Uncertainty in Trend in Total Emissions due to EF	Uncertainty in Trend in Total Emissions due to AD	Combined Uncertainty in Total Emissions
3 Agriculture, Forestry and Other Land Use		$ktCO_2eq$	$ktCO_2eq$	%	%	%	%			%	%	%
3ALivestock												
3A1 Enteric fermentation	CH_4											
Dairy cattle	CH_4	520.33	1,394.53	20.00%	20.00%	28.28%	0.00%	0.01400	0.02653	0.28%	0.75%	0.01%
Other cattle (Beef cattle)	CH_4	6,447.75	10,386.05	20.00%	20.00%	28.28%	0.20%	0.04236	0.19756	0.85%	5.59%	0.32%
Buffalo	CH_4	3,193.07	2,839.20	20.00%	20.00%	28.28%	0.01%	0.02281	0.05401	0.46%	1.53%	0.03%
Sheep	CH_4	5.22	15.81	20.00%	50.00%	53.85%	0.00%	0.00017	0.00030	0.01%	0.01%	0.00%
Goats	CH_4	20.19	178.80	20.00%	50.00%	53.85%	0.00%	0.00292	0.00340	0.15%	0.10%	0.00%
Swine	CH_4	325.96	550.36	20.00%	50.00%	53.85%	0.00%	0.00263	0.01047	0.13%	0.30%	0.00%
3A2 Manure management (CH_4)	CH_4											
Dairy cattle	CH_4	120.87	323.94	20.00%	20.00%	28.28%	0.00%	0.00325	0.00616	0.07%	0.17%	0.00%
Other cattle (Beef cattle)	CH_4	731.83	1,187.71	20.00%	20.00%	28.28%	0.00%	0.00498	0.02259	0.10%	0.64%	0.00%
Buffalo	CH_4	123.07	109.43	20.00%	20.00%	28.28%	0.00%	0.00088	0.00208	0.02%	0.06%	0.00%
Sheep	CH_4	0.21	0.63	20.00%	20.00%	28.28%	0.00%	0.00001	0.00001	0.00%	0.00%	0.00%
Goats	CH_4	0.89	7.87	20.00%	30.00%	36.06%	0.00%	0.00013	0.00015	0.00%	0.00%	0.00%
Swine	CH_4	505.65	915.80	20.00%	30.00%	36.06%	0.00%	0.00525	0.01742	0.16%	0.49%	0.00%
Poultry	CH_4	121.65	290.44	20.00%	30.00%	36.06%	0.00%	0.00260	0.00552	0.08%	0.16%	0.00%
3A2 Manure management (Direct N_2O emission)	N_2O											
Dairy cattle	N_2O	29.41	77.25	53.85%	111.80%	124.09%	0.00%	0.00076	0.00147	0.09%	0.11%	0.00%
Other cattle (Beef cattle)	N_2O	140.66	234.56	53.85%	111.80%	124.09%	0.00%	0.00108	0.00446	0.12%	0.34%	0.00%
Buffalo	N_2O	180.64	159.87	53.85%	111.80%	124.09%	0.00%	0.00131	0.00304	0.15%	0.23%	0.00%
Sheep	N_2O	0.76	2.30	53.85%	111.80%	124.09%	0.00%	0.00003	0.00004	0.00%	0.00%	0.00%
Goats	N_2O	3.69	32.71	53.85%	111.80%	124.09%	0.00%	0.00053	0.00062	0.06%	0.05%	0.00%
Swine	N_2O	14.84	26.53	53.85%	111.80%	124.09%	0.00%	0.00015	0.00050	0.02%	0.04%	0.00%
Poultry	N_2O	45.28	103.03	53.85%	111.80%	124.09%	0.00%	0.00087	0.00196	0.10%	0.15%	0.00%
3C Aggregate sources and non-CO_2 emissions sources on land												
3C1b Emissions from biomass burning	CH_4, N_2O											
3C1b Biomass burning in croplands (CH_4)	CH_4	955.42	1,298.44	0.00%	100.00%	100.00%	0.04%	0.00171	0.02470	0.17%	0.00%	0.00%
3C1b Biomass burning in croplands (N_2O)	N_2O	234.43	318.60	0.00%	100.00%	100.00%	0.00%	0.00042	0.00606	0.04%	0.00%	0.00%
3C2 Liming	CO_2	-	16.37	0.00%	50.00%	50.00%	0.00%	0.00031	0.00031	0.02%	0.00%	0.00%
3C3 Urea application	CO_2	1,092.95	1,294.18	0.00%	50.00%	50.00%	0.01%	0.00168	0.02462	0.08%	0.00%	0.00%
3C4 Direct N_2O emissions from managed soils	N_2O											
(1) Synthetic fertilizers	N_2O											
Synthetic fertilizers - EF_1	N_2O	2,264.68	2,686.00	0.00%	200.00%	200.00%	0.65%	0.00340	0.05109	0.68%	0.00%	0.00%
Synthetic fertilizers - EF_{1FR}	N_2O	536.16	625.14	0.00%	100.00%	100.00%	0.01%	0.00101	0.01189	0.10%	0.00%	0.00%
(2) Manure - EF_1	N_2O	649.61	1,271.98	0.00%	269.13%	269.13%	0.26%	0.00856	0.02419	2.30%	0.00%	0.05%
(3) Crop residues	N_2O											
Crop residues - EF_1	N_2O	820.57	1,256.14	0.00%	203.38%	203.38%	0.15%	0.00415	0.02389	0.84%	0.00%	0.01%
Crop residues - EF_{1FR}	N_2O	107.68	126.60	0.00%	106.60%	106.60%	0.00%	0.00018	0.00241	0.02%	0.00%	0.00%

Table 2-143: GHG emissions and uncertainty analysis in the Agriculture sector in 2021 (Cont'd)

IPCC Category	Greenhouse Gas	Emissions or removals in 2000	Emissions or removals in 2022	Activity Data (AD) Uncertainty	Emission Factor (EF) Uncertainty	Combined Uncertainty	Combined Uncertainty as % of Emissions in 2001	Type A Sensitivity	Type B Sensitivity	Uncertainty in Trend in Total Emissions due to EF	Uncertainty in Trend in Total Emissions due to AD	Combined Uncertainty in Trend in Total Emissions
3 Agriculture, Forestry and Other Land Use		$ktCO_2eq$	$ktCO_2eq$	%	%	%	%			%	%	%
(4) Organic soils	N_2O	-	-	0.00%	200.00%	200.00%	0.00%	0.00000	0.00000	0.00%	0.00%	0.00%
(5) Manure (pasture)	N_2O	1,210.78	1,703.70	53.85%	206.16%	213.08%	0.30%	0.00327	0.03241	0.67%	2.47%	0.07%
3C5 Indirect N_2O emissions from managed soils	N_2O											
Volatilization (EF_4)												
(1) Synthetic fertilizers	N_2O	405.19	476.98	0.00%	447.21%	447.21%	0.10%	0.00068	0.00907	0.30%	0.00%	0.00%
(2) Manure	N_2O	251.20	426.30	0.00%	463.60%	463.60%	0.09%	0.00206	0.00811	0.96%	0.00%	0.01%
Leaching (EF_5)												
(1) Synthetic fertilizers	N_2O	911.68	1,073.20	0.00%	286.67%	286.67%	0.21%	0.00152	0.02041	0.44%	0.00%	0.00%
(2) Manure	N_2O	282.60	479.59	0.00%	338.54%	338.54%	0.06%	0.00232	0.00912	0.79%	0.00%	0.01%
(3) Crop residues	N_2O	265.39	377.58	0.00%	289.03%	289.03%	0.03%	0.00080	0.00718	0.23%	0.00%	0.00%
3C6 Indirect N_2O emissions from manure management	N_2O	312.97	604.07	53.85%	423.25%	426.66%	0.15%	0.00396	0.01149	1.68%	0.88%	0.04%
3C7 Rice cultivations	CH_4											
Major rice	CH_4											
(1) SF_w-irrigated	CH_4	9,300.50	10,819.76	0.00%	78.68%	78.68%	1.64%	0.01795	0.20580	1.41%	0.00%	0.02%
(2) SF_w-rainfed (regular)	CH_4	4,564.45	4,538.14	0.00%	78.26%	78.26%	0.29%	0.02349	0.08632	1.84%	0.00%	0.03%
(3) SF_w-rainfed (drought prone)	CH_4	11,879.54	13,457.70	0.00%	83.89%	83.89%	2.88%	0.02979	0.25598	2.50%	0.00%	0.06%
(4) SF_w-rainfed (deep water)	CH_4	157.74	161.49	0.00%	122.89%	122.89%	0.00%	0.00072	0.00307	0.09%	0.00%	0.00%
Second rice (SF_w-irrigated)	CH_4	3,837.42	4,654.51	0.00%	78.68%	78.68%	0.30%	0.00380	0.08853	0.30%	0.00%	0.00%
Total		**52,572.93**	**66,503.31**				**7.40%**					**0.67%**
						Percentage uncertainty in total inventory =	**27.20%**				**Trend uncertainty =**	**8.16%**

Note: For Type A sensitivity, use the equation: ABS[((0.01xD + TotalD)/(0.01xC + TotalC) - 1) x 100 - (TotalD/TotalC -1) x 100].

Table 2-144: GHG emissions and uncertainty analysis in the Agriculture sector in 2022

IPCC Category	Greenhouse Gas	Emissions or removals in 2000	Emissions or removals in 2022	Activity Data (AD) Uncertainty	Emission Factor (EF) Uncertainty	Combined Uncertainty	Combined Uncertainty as % of Emissions in 2001	Type A Sensitivity	Type B Sensitivity	Uncertainty in Trend in Total Emissions due to EF	Uncertainty in Trend in Total Emissions due to AD	Combined Uncertainty in Trend in Total Emissions
3 Agriculture, Forestry and Other Land Use		$ktCO_2eq$	$ktCO_2eq$	%	%	%	%			%	%	%
3ALivestock												
3A1 Enteric fermentation	CH_4											
Dairy cattle	CH_4	520.33	1,402.57	20.00%	20.00%	28.28%	0.00%	0.01370	0.02668	0.27%	0.75%	0.01%
Other cattle (Beef cattle)	CH_4	6,447.75	13,001.76	20.00%	20.00%	28.28%	0.28%	0.08639	0.24731	1.73%	6.99%	0.52%
Buffalo	CH_4	3,193.07	3,262.30	20.00%	20.00%	28.28%	0.02%	0.01757	0.06205	0.35%	1.76%	0.03%
Sheep	CH_4	5.22	17.96	20.00%	50.00%	53.85%	0.00%	0.00021	0.00034	0.01%	0.01%	0.00%
Goats	CH_4	20.19	210.75	20.00%	50.00%	53.85%	0.00%	0.00351	0.00401	0.18%	0.11%	0.00%
Swine	CH_4	325.96	451.89	20.00%	50.00%	53.85%	0.00%	0.00047	0.00860	0.02%	0.24%	0.00%
3A2 Manure management (CH_4)	CH_4											
Dairy cattle	CH_4	120.87	325.80	20.00%	20.00%	28.28%	0.00%	0.00318	0.00620	0.06%	0.18%	0.00%
Other cattle (Beef cattle)	CH_4	731.83	1,487.05	20.00%	20.00%	28.28%	0.00%	0.01003	0.02829	0.20%	0.80%	0.01%
Buffalo	CH_4	123.07	125.74	20.00%	20.00%	28.28%	0.00%	0.00068	0.00239	0.01%	0.07%	0.00%
Sheep	CH_4	0.21	0.72	20.00%	20.00%	28.28%	0.00%	0.00001	0.00001	0.00%	0.00%	0.00%
Goats	CH_4	0.89	9.27	20.00%	30.00%	36.06%	0.00%	0.00015	0.00018	0.00%	0.00%	0.00%
Swine	CH_4	505.65	756.56	20.00%	30.00%	36.06%	0.00%	0.00178	0.01439	0.05%	0.41%	0.00%
Poultry	CH_4	121.65	298.18	20.00%	30.00%	36.06%	0.00%	0.00264	0.00567	0.08%	0.16%	0.00%
3A2 Manure management (Direct N_2O emission)	N_2O											
Dairy cattle	N_2O	29.41	77.20	53.85%	111.80%	124.09%	0.00%	0.00073	0.00147	0.08%	0.11%	0.00%
Other cattle (Beef cattle)	N_2O	140.66	295.23	53.85%	111.80%	124.09%	0.00%	0.00211	0.00562	0.24%	0.43%	0.00%
Buffalo	N_2O	180.64	184.37	53.85%	111.80%	124.09%	0.00%	0.00100	0.00351	0.11%	0.27%	0.00%
Sheep	N_2O	0.76	2.62	53.85%	111.80%	124.09%	0.00%	0.00003	0.00005	0.00%	0.00%	0.00%
Goats	N_2O	3.69	38.56	53.85%	111.80%	124.09%	0.00%	0.00064	0.00073	0.07%	0.06%	0.00%
Swine	N_2O	14.84	20.96	53.85%	111.80%	124.09%	0.00%	0.00003	0.00040	0.00%	0.03%	0.00%
Poultry	N_2O	45.28	107.75	53.85%	111.80%	124.09%	0.00%	0.00092	0.00205	0.10%	0.16%	0.00%
3C Aggregate sources and non-CO_2 emissions sources on land												
3C1b Emissions from biomass burning	CH_4, N_2O											
3C1b Biomass burning in croplands (CH_4)	CH_4	955.42	1,356.02	0.00%	100.00%	100.00%	0.04%	0.00196	0.02579	0.20%	0.00%	0.00%
3C1b Biomass burning in croplands (N_2O)	N_2O	234.43	332.73	0.00%	100.00%	100.00%	0.00%	0.00048	0.00633	0.05%	0.00%	0.00%
3C2 Liming	CO_2	-	16.02	0.00%	50.00%	50.00%	0.00%	0.00030	0.00030	0.02%	0.00%	0.00%
3C3 Urea application	CO_2	1,092.95	1,049.85	0.00%	50.00%	50.00%	0.01%	0.00729	0.01997	0.36%	0.00%	0.00%

Table 2-144: GHG emissions and uncertainty analysis in the Agriculture sector in 2022 (Cont'd)

IPCC Category	Greenhouse Gas	Emissions or removals in 2000	Emissions or removals in 2022	Activity Data (AD) Uncertainty	Emission Factor (EF) Uncertainty	Combined Uncertainty	Combined Uncertainty as % of Emissions in 2001	Type A Sensitivity	Type B Sensitivity	Uncertainty in Trend in Total Emissions due to EF	Uncertainty in Trend in Total Emissions due to AD	Combined Uncertainty in Trend in Total Emissions
3 Agriculture, Forestry and Other Land Use		$ktCO_2eq$	$ktCO_2eq$	%	%	%	%			%	%	%
3C4 Direct N_2O emissions from managed soils	N_2O											
(1) Synthetic fertilizers	N_2O											
Synthetic fertilizers - EF_1	N_2O	2,264.68	1,638.45	0.00%	200.00%	200.00%	0.23%	0.02531	0.03117	5.06%	0.00%	0.26%
Synthetic fertilizers - EF_{1FR}	N_2O	536.16	635.85	0.00%	100.00%	100.00%	0.01%	0.00128	0.01209	0.13%	0.00%	0.00%
(2) Manure - EF_1	N_2O	649.61	1,297.27	0.00%	269.13%	269.13%	0.26%	0.00847	0.02468	2.28%	0.00%	0.05%
(3) Crop residues	N_2O											
Crop residues - EF_1	N_2O	820.57	1,255.36	0.00%	203.38%	203.38%	0.14%	0.00341	0.02388	0.69%	0.00%	0.00%
Crop residues - EF_{1FR}	N_2O	107.68	135.40	0.00%	106.60%	106.60%	0.00%	0.00011	0.00258	0.01%	0.00%	0.00%
(4) Organic soils	N_2O	-	-	0.00%	200.00%	200.00%	0.00%	0.00000	0.00000	0.00%	0.00%	0.00%
(5) Manure (pasture)	N_2O	1,210.78	1,999.45	53.85%	206.16%	213.08%	0.38%	0.00783	0.03803	1.61%	2.90%	0.11%
3C5 Indirect N_2O emissions from managed soils	N_2O											
Volatilisation (EF_4)												
(1) Synthetic fertilizers	N_2O	405.19	375.79	0.00%	447.21%	447.21%	0.06%	0.00296	0.00715	1.32%	0.00%	0.02%
(2) Manure	N_2O	251.20	461.21	0.00%	463.60%	463.60%	0.10%	0.00251	0.00877	1.16%	0.00%	0.01%
Leaching (EF_5)												
(1) Synthetic fertilizers	N_2O	911.68	845.53	0.00%	286.67%	286.67%	0.12%	0.00665	0.01608	1.91%	0.00%	0.04%
(2) Manure	N_2O	282.60	518.86	0.00%	338.54%	338.54%	0.06%	0.00282	0.00987	0.96%	0.00%	0.01%
(3) Crop residues	N_2O	265.39	384.01	0.00%	289.03%	289.03%	0.03%	0.00069	0.00730	0.20%	0.00%	0.00%
3C6 Indirect N_2O emissions from manure management	N_2O	312.97	667.90	53.85%	423.25%	426.66%	0.17%	0.00490	0.01270	2.07%	0.97%	0.05%
3C7 Rice cultivations	CH_4											
Major rice	CH_4											
(1) SF_w-irrigated	CH_4	9,300.50	10,853.23	0.00%	78.68%	78.68%	1.53%	0.02547	0.20644	2.00%	0.00%	0.04%
(2) SF_w-rainfed (regular)	CH_4	4,564.45	4,528.50	0.00%	78.26%	78.26%	0.26%	0.02768	0.08614	2.17%	0.00%	0.05%
(3) SF_w-rainfed (drought prone)	CH_4	11,879.54	13,181.36	0.00%	83.89%	83.89%	2.57%	0.04546	0.25073	3.81%	0.00%	0.15%
(4) SF_w-rainfed (deep water)	CH_4	157.74	161.02	0.00%	122.89%	122.89%	0.00%	0.00087	0.00306	0.11%	0.00%	0.00%
Second rice (SF_w-irrigated)	CH_4	3,837.42	5,162.68	0.00%	78.68%	78.68%	0.35%	0.00249	0.09820	0.20%	0.00%	0.00%
Total		52,572.93	68,933.74				6.64%					1.36%
						Percentage uncertainty in total inventory =	**25.76%**				Trend uncertainty =	**11.66%**

Table 2-145: Uncertainties of the GHG inventory in the Agriculture sector for 2000-2022

Year	Uncertainty (%) (Agriculture sector)	
	In total inventory	Trend
2000	28.75	4.33
2001	28.46	5.03
2002	27.89	4.93
2003	28.10	5.26
2004	27.85	5.39
2005	27.22	7.11
2006	26.85	7.14
2007	26.99	7.71
2008	26.21	9.09
2009	26.97	9.13
2010	29.15	8.40
2011	28.63	9.69
2012	28.53	10.62
2013	30.14	9.09
2014	30.45	8.65
2015	30.43	6.00
2016	31.32	7.79
2017	30.65	9.83
2018	28.59	7.65
2019	27.86	7.10
2020	28.64	6.45
2021	27.20	8.16
2022	25.76	11.66

2.4 WASTE SECTOR

Overview of Emissions in the Waste Sector

Thailand reports its greenhouse gas (GHG) emissions from the waste sector in accordance with the requirements of the United Nations Framework Convention on Climate Change (UNFCCC). The approaches for estimating greenhouse gas emissions are based on the "2006 IPCC Guidelines for National Greenhouse Gas Inventories" and the “2019 Refinement to the 2006 IPCC Guidelines”. These guidelines provide methodologies and parameters for calculating GHG emissions from waste management, i.e., solid waste management and wastewater treatment and discharge. The GHG inventory for the waste sector is divided into four subsectors below and Table 2-146 provides a summary of calculation tiers and sources of emission factors used in estimating greenhouse gas emissions from each subsector of the waste sector.

1. **5A Solid Waste Disposal**
   5A1 Managed Waste Disposal Sites
   5A2 Unmanaged Waste Disposal Sites
   5A3 Uncategorized Waste Disposal Sites
2. **5B Biological Treatment of Solid Waste**
3. **5C Incineration and Open Burning of Waste**
   5C1 Waste Incineration
   5C2 Open Burning of Waste
4. **5D Wastewater Treatment and Discharge**
   5D1 Domestic Wastewater Treatment and Discharge
   5D2 Industrial Wastewater Treatment and Discharge

Table 2-146: Methodologies used in the Waste sector

GHG source and sink categories	CO_2		CH_4		N_2O		NO_x		CO		NMVOCs		SO_2	
	Method applied	EF	Method applied	EF	Method applied	EF	Method applied	EF	Method applied	EF	Method applied	EF	Method applied	EF
5 Waste	T1	D	T1, T2	CS, D	T1	D								
5A Solid Waste Disposal			T2	CS, D										
5B Biological Treatment of Solid Waste			T1	D	T1	D								
5C Incineration and Open Burning of Waste	T1	D	T1	D	T1	D								
5D Wastewater Treatment and Discharge			T1	D	T1	D								

Note: T1: Tier 1, T2: Tier 2, T3: Tier 3, EF: Emission factor, CS: Country Specific, D: IPCC default

Solid Waste Disposal (5A)

Category Description

For greenhouse gas emissions from solid waste disposal, emission activities are categorized into three subsectors: 5A1 - Managed Waste Disposal Sites, 5A2 - Unmanaged Waste Disposal Sites, and 5A3 - Uncategorized Waste Disposal Sites. The estimation of greenhouse gas emissions from solid waste disposal is based on the decomposition of degradable organic carbon (DOC) in solid waste, which gradually breaks down and generates methane (CH_4) and carbon dioxide (CO_2). However, the CO_2 produced is considered as biogenic carbon dioxide, originating from the decomposition of organic materials derived from biomass, such as wood scraps, corn husks, and coconut shells. Therefore, CO_2 is not included in the waste sector. CH_4 is generated as a result of degradation of organic material under anaerobic conditions. Part of the CH_4 generated is oxidized in the cover of the SWDS, or can be recovered for energy or flaring. Eventually, the CH_4 emissions from solid waste disposal for a single year can be estimated.

Estimation Method

According to the 2006 IPCC Guidelines, methane emissions from waste disposal are calculated using the First-Order Decay (FOD) model. This model is based on an exponential function that describes the fraction of degradable material that breaks down into CH_4 and CO_2 each year. A key input is the amount of degradable organic carbon (DOCm) in the waste disposed of at SWDS, estimated based on the types of waste (e.g., food, paper, wood, textiles). The calculation basis is the amount of decomposable degradable organic carbon (DDOCm), which represents the portion of organic carbon that will degrade under anaerobic conditions in SWDS. The DDOCm is determined by the product of the waste amount (W), the fraction of degradable organic carbon in the waste (DOC), the fraction of the degradable organic carbon that decomposes under anaerobic conditions (DOCf), and the part of the waste that will decompose under aerobic conditions (prior to the conditions becoming anaerobic) in the SWDS, which is interpreted with the methane correction factor (MCF).

Methane emissions are highest during the first 1-3 years of landfill, then gradually decline. Emissions depend on several factors, including the quantity, composition, moisture content of the waste, and landfill management practices. In general, higher organic content and moisture levels lead to increased methane production. Sanitary landfills have a higher potential for methane generation compared to unmanaged landfills (controlled and open dumps), as aerobic decomposition primarily occurs in the upper waste layers of managed sites. In unmanaged landfills, thicker waste layers increase the potential for methane generation.

The following steps represent the estimation methods for methane emission, based on the First Order Decay (FOD) (IPCC, 2006).

1) $DDOC_m$ deposited into the SWDS in year T ($DDOC_{mdT}$)

The term "decomposable degradable organic carbon ($DDOC_m$) deposited into the SWDS" refers to the portion of organic carbon found in waste materials that can decompose over time after being placed in a disposal site in the inventory year T. The data can be given by waste type (waste composition option) or as bulk waste. In the waste composition option, waste is split by waste type/material (paper and cardboard, food garden and park waste, wood, textiles and other waste). Not all DOC_m entering the site will decompose under the anaerobic conditions in the SWDS. The parameter DOC_f is the fraction of DOC_m which will actually degrade in the SWDS. The decomposable degradable organic carbon ($DDOC_m$) deposited into the SWDS in year T ($DDOC_{mdT}$) is calculated by Eq. 5-1 (refer to Eq. 3A1.16 from the 2006 IPCC guidelines vol.5).

$$DDOC_{mdT} = W_{x,T} \cdot DOC_x \cdot DOC_f \cdot MCF \qquad (5\text{-}1)$$

Where:

$DDOC_{mdT}$	=	decomposable degradable organic carbon ($DDOC_m$) deposited into the SWDS in year T (Gg)
$W_{x,T}$	=	mass of waste type x deposited into the SWDS in year T (Gg)
x	=	waste type/material or waste category
T	=	inventory year
DOC_x	=	degradable organic carbon in waste type x in disposal year (fraction)
DOC_f	=	fraction of DOC that can decompose in the anaerobic conditions in the SWDS (fraction)
MCF	=	methane correction factor for year of disposal.

2) $DDOC_m$ remaining and decomposed at end of year of disposal ($DDOC_{m\ remT}$ and ($DDOC_{m\ decT}$)

Typically, it is assumed that anaerobic decomposition of $DDOC_m$ to CH_4 begins on 1st of January in the year after disposal (an average delay of 6 months before the decay reaction begins). In case the anaerobic decomposition is set to start earlier than this, i.e., in the year of disposal, separate calculations will have to be made for the year of disposal. Considering a different time delay (M), the $DDOC_m$ remaining at the end of disposal year ($DDOC_{m\ remT}$) is estimated by Eq. 5-2, whereas the $DDOC_m$ decomposed at end of year of disposal ($DDOC_{m\ decT}$) is calculated using Eq. 5-3 (refer to Eqs. 3A1.12 and 3A1.13, respectively, in the 2006 IPCC guidelines vol.5).

$$DDOC_{m\ remT} = DDOC_{mdT} \cdot \left[e^{-k(13-M)/12}\right] \qquad (5\text{-}2)$$

$$DDOC_{m\ decT} = DDOC_{mdT} \cdot \left[1 - e^{-k(13-M)/12}\right] \qquad (5\text{-}3)$$

Where:

$DDOC_{m\ remT}$	=	$DDOC_m$ disposed in year T which still remains at the end of year T (Gg)
$DDOC_{mdT}$	=	$DDOC_m$ disposed in year T (Gg)
$DDOC_{m\ decT}$	=	$DDOC_m$ disposed in year T which has decomposed by the end of year T (Gg)
T	=	year T (inventory year)
M	=	month when reaction is set to start, equal to the average delay time +7 (month)
k	=	rate of reaction constant (y-1).

3) $DDOC_m$ accumulated at the end of year T ($DDOC_{maT}$)

The term "$DDOC_m$ accumulated at the end of year T ($DDOC_{maT}$)" refers to the total amount of decomposable degradable organic carbon ($DDOC_m$) that has accumulated in the SWDS by the end of year T. This accumulated amount is calculated by combining two factors: the remaining $DDOC_m$ at the end of the disposal year T ($DDOC_{m\ remT}$) and the remaining $DDOC_m$ from the previous year, T-1, as shown in Eq. 5-4 (refer to Eq. 3A1.14 in the 2006 IPCC guidelines vol.5). Essentially, it represents the build-up of organic carbon that has not yet decomposed in the disposal site over time.

$$DDOC_{maT} = DDOC_{m\ remT} + (DDOC_{maT-1} \cdot e^{-k(13-M)/12}) \tag{5-4}$$

Where:

$DDOC_{maT}$	=	$DDOC_m$ accumulated in the SWDS at the end of year T (Gg)
$DDOC_{m\ remT}$	=	$DDOC_m$ disposed in year T which still remains at the end of year T (Gg)
$DDOC_{maT-1}$	=	$DDOC_m$ accumulated in the SWDS at the end of year T−1 (Gg)
T	=	year T (inventory year)
M	=	month when reaction is set to start, equal to the average delay time + 7 (month)
k	=	rate of reaction constant (y-1).

4) $DDOC_m$ decomposed during year of disposal ($DDOC_{m\ decompT}$)

The amount of $DDOC_m$ decomposed in year T is estimated by a summation of the $DDOC_m$ decomposed by the end of year T and the accumulated $DDOC_m$ in the SWDS at the end of year T−1 which is further decomposed by the end of year T, according to Eq. 5-5 (refer to Eq. 3A1.15 from the 2006 IPCC guidelines vol.5). This generates CH_4 as follows:

$$DDOC_{decomp\ T} = DDOC_{m\ decT} + DDOC_{maT-1} \cdot [1 - e^{-k(13-M)/12}] \tag{5-5}$$

Where:

$DDOC_{decompT}$	=	$DDOC_m$ decomposed in year T (Gg)
$DDOC_{m\ decT}$	=	$DDOC_m$ disposed in year T which has decomposed by the end of year T (Gg)
$DDOC_{maT-1}$	=	$DDOC_m$ accumulated in the SWDS at the end of year T−1 (Gg)
k	=	rate of reaction constant (y-1).

5) Methane generation from $DDOC_m$ decomposed

The amount of CH_4 generated from the $DDOC_m$ which decomposes in year T is calculated by Eq. 5-6 (refer to Eq. 3A1.17 from the 2006 IPCC guidelines vol.5).

$$CH_{4\ generated\ T} = DDOC_{m\ decomp\ T} \cdot F \cdot \frac{16}{12} \tag{5-6}$$

Where:

CH_4 generated$_T$	= amount of CH_4 generated from the $DDOC_m$ which decomposes (Gg)
$DDOC_{m\ decompT}$ =	$DDOC_m$ decomposed in year T (Gg)
F	= fraction of CH_4, by volume, in generated landfill gas (fraction)
$\frac{16}{12}$	= molecular weight ratio CH_4/C (ratio).

6) Methane emission from the SWDS

The CH_4 generated by each category of waste disposed is added to get total CH_4 generated in each year. Finally, emissions of CH_4 are calculated by subtracting first the CH_4 gas recovered from the disposal site, and then CH_4 oxidized to carbon dioxide in the cover layer, as shown in Eq. 5-7 (refer to Eq. 3A1.18 from the 2006 IPCC guidelines vol.5).

$$CH_{4\ Emissions\ T} = \left[\sum_x CH_{4\ generated\ x,T} - R_T\right] \cdot (1 - OX_T) \quad (5\text{-}7)$$

Where:

$CH_{4\ Emissions\ T}$	=	CH_4 emitted in year T (Gg)
$CH_{4\ generated\ x,T}$	=	amount of CH_4 generated from the $DDOC_m$ of waste type x which decomposes in year T (Gg)
R_T	=	CH_4 recovered in year T (Gg)
OX_T	=	oxidation factor in year T (fraction).

7) Activity Data of Solid Waste Disposal (5A)

The activity data used for calculating greenhouse gas emissions from solid waste disposal includes the quantity and composition of waste, waste disposal methods, and methane recovery. These data are provided by the Pollution Control Department (PCD), the Bangkok Metropolitan Administration (BMA), and the Department of Alternative Energy Development and Efficiency (DEDE). Waste quantity and disposal methods from the PCD are reported for approximately 3,000 waste disposal sites nationwide. All the data of each disposal site were collected and archived by the sectoral focal point and the TGEIS database. In this report, the disposal sites are categorized according to the waste management methods aligning with the 2006 IPCC Guidelines, as listed in Table 2-147. The aggregated amounts of solid waste delivered to the solid waste disposal site (SWDS) in the years 2020-2021, categorized by type of waste, are reported in Table 2-148.

Waste composition data is drawn from studies conducted by the PCD in 2005 and 2013, along with annual survey data from the Environmental and Pollution Control Offices (EPO). During 2000-2020, regional average data is applied in calculations for individual disposal sites located in specific regions of each EPO, as listed in Table 2-419. For 2021-2022, the PCD conducted a comprehensive national study on waste composition, and since then, weighted-average composition data has been updated and applied to represent disposal sites across the country, except the SWDS of BMA. For the Bangkok area, waste composition data from the BMA is used specifically to calculate greenhouse gas emissions, as shown in Table 2-150. Methane recovery data for electricity and/or heat generation from waste, covering 2020-2022, is provided by the DEDE and presented in Table 2-151.

Table 2-147: Thailand's waste management methods aligned with the 2006 IPCC Guidelines

2006 IPCC Guidelines/ TGEIS	Thailand's waste management methods
Managed anaerobic waste disposal sites	Landfill
Unmanaged - deep disposal sites	Control dump
Unmanaged - shallow disposal sites	Open dump

Table 2-148: Annual waste amount at the disposal sites categorized by type of waste

Greenhouse gas source and sink categories	Annual waste at the SWDS (kt)		
	2020	2021	2022
5.A.1. Managed waste disposal sites			
5.A.1.a. Anaerobic	**4,855.10**	**9,790.70**	**9,846.79**
Less decomposable wastes	0.00	42.67	337.11
Moderately decomposable wastes	804.83	1,623.54	1,552.04
Highly decomposable waste	2,718.42	4,964.34	4,832.28
Other composition	1,331.85	3,160.16	3,125.36
5.A.1.b. Semi-aerobic	**3.29**	**0.73**	**1.46**
Less decomposable wastes	0.00	0.01	0.02
Moderately decomposable wastes	0.27	0.09	0.19
Highly decomposable waste	2.17	0.35	0.70
Other composition	0.84	0.28	0.55
5.A.2. Unmanaged waste disposal sites-Deep	**3,335.28**	**1,563.54**	**3,375.19**
Less decomposable wastes	0.00	18.61	40.16
Moderately decomposable wastes	458.80	202.79	437.76
Highly decomposable waste	1,811.66	748.00	1,614.69
Other composition	1,064.82	594.15	1,282.57
5.A.2. Unmanaged waste disposal sites-Shallow	**4,892.94**	**4,259.31**	**3,709.95**
Less decomposable wastes	0.00	50.69	44.15
Moderately decomposable wastes	630.49	552.43	481.18
Highly decomposable waste	2,824.83	2,037.65	1,774.84
Other composition	1,437.62	1,618.54	1,409.78
Total amount of waste at the SWDS (kt)	**13,086.61**	**15,614.28**	**16,933.39**

Table 2-149: Regional average data of waste composition data for 2000-2022

Waste composition	Regional average data of waste composition (% by weight)																	
	Year 2000-2020																2021	2022
	EPO. 1	EPO. 2	EPO. 3	EPO. 4	EPO. 5	EPO. 6	EPO. 7	EPO. 8	EPO. 9	EPO. 10	EPO. 11	EPO. 12	EPO. 13	EPO. 14	EPO. 15	EPO. 16	Overall	
Food	37.55	35.90	40.87	49.42	51.04	51.04	56.57	55.89	60.79	70.88	65.58	70.88	59.34	47.59	58.42	36.09	38.76	38.76
Paper	11.49	12.95	9.98	9.83	12.00	12.00	10.30	9.02	6.64	6.31	7.14	6.31	8.40	12.31	8.96	13.05	6.27	6.27
Garden	9.57	9.91	9.73	6.35	2.13	2.13	4.00	4.87	4.22	0.46	0.60	0.46	0.90	4.61	1.15	8.63	9.08	9.08
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.19	1.19
Others	4.49	2.53	3.08	3.04	0.83	1.94	1.42	1.53	0.80	0.00	0.00	0.00	0.00	2.43	3.48	4.88	2.53	2.53
Textiles	3.68	2.92	2.66	2.18	2.97	2.97	1.24	1.88	2.27	0.85	1.00	0.85	1.89	1.89	1.35	2.52	3.04	3.04
Sludge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nappies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.66	3.66
Rubber and Leather	1.68	3.13	3.05	2.18	1.81	1.81	0.84	1.24	0.76	0.32	0.52	0.32	0.56	1.71	0.58	2.72	1.32	1.32
Plastic	17.18	17.66	15.48	13.97	17.25	15.94	17.94	15.19	17.44	16.03	17.29	14.66	18.58	17.06	17.86	16.49	28.13	28.13
Metal	4.10	4.37	5.79	3.42	3.50	3.81	2.09	2.54	1.70	1.65	2.23	1.65	2.60	3.23	1.96	3.81	3.95	3.95
Glass	7.12	6.18	6.15	6.34	5.12	5.09	2.86	4.10	2.71	2.54	3.55	2.66	3.30	5.87	5.05	8.09	1.56	1.56
Stone and Ceramic	3.14	4.45	3.21	3.27	3.35	3.27	2.74	3.74	2.67	0.96	2.09	2.21	4.43	3.30	1.19	3.72	0.51	0.51

Table 2-150: Waste composition data of BMA for 2020-2022

Waste composition	Waste composition (% by weight)		
	2020	2021	2022
Food	45.41	46.46	49.83
Paper	14.02	12.14	11.28
Garden	5.76	5.90	0.00
Wood	0.00	0.00	4.79
Others	1.10	1.25	2.92
Textiles	4.15	5.61	5.48
Sludge	0.00	0.00	0.00
Nappies	2.00	0.92	0.71
Rubber and Leather	1.05	1.07	1.43
Plastic	22.58	22.86	19.81
Metal	2.30	2.07	1.34
Glass	1.38	1.24	1.50
Stone and Ceramic	0.25	0.48	0.91

Table 2-151: Methane recovery data for electricity and/or heat generation from waste for 2020-2022

Year	Methane utilized for electricity and/or heat	
	$ktCH_4$	$ktCO_2eq$
2020	58.35	1,633.73
2021	64.96	1,819.00
2022	66.70	1,867.49

Emission Factors of Solid Waste Disposal (5A)

Greenhouse gas emission factors used in the calculation are based on the recommendations in the 2006 IPCC Guidelines, as detailed in Table 2-152.

Table 2-152: Emission factors of solid waste disposal (5A) for 2000-2022

Parameters	Unit	Item	value	Reference
Degradable organic carbon (DOC)	fraction	Food	0.15	2006 IPCC GLs
		Paper/Cardboard	0.40	
		Garden	0.20	
		Textile	0.24	
		Wood	0.43	
		Nappies	0.24	
Methane correction factor (MCF)	fraction	Managed-anaerobic	1.0	2006 IPCC GLs
		Managed-semi aerobic	0.5	
		Unmanaged-deep	0.8	
		Unmanaged-shallow	0.4	
		Uncategorized	0.6	
Methane generation rate constant (k)	yr-1	Food/Garden (Highly decomposable)	0.4/0.17	2006 IPCC GLs/ 2019 IPCC refinement
		Paper/Textile (Moderately decomposable)	0.07	
		Wood (Less decomposable)	0.035	
Fraction of degradable organic carbon which composes (DOCf)	fraction	-	0.5	2006 IPCC GLs
Fraction of methane in generated landfill gas (F)	fraction	-	0.55	2006 IPCC GLs
Oxidation factor	fraction	Managed-covered with methane oxidizing material	0.1	2006 IPCC GLs
		Unmanaged/Uncategorized SWDS	0	

Uncertainties

The uncertainty analysis of greenhouse gas emissions calculations from solid waste disposal (5A) is divided into two parts consisting of:

- uncertainty analysis associated with Activity Data (AD), which includes the amount of waste entering the SWDS and the waste composition. This analysis employed the default values in the 2006 IPCC Guidelines for the quantity of waste generated and disposed of which is in a range of ±42.43%.

- uncertainty analysis associated with Emission Factor (EF), which is set at an uncertainty range of ±71.67%.

When calculating the total uncertainty for the solid waste disposal (5A), the resulting value of uncertainty is ±83.29%, as shown in Table 2-153.

Table 2-153: Uncertainty analysis of solid waste disposal (5A)

Parameters	Data source	value	Uncertainty Range		Reference
			High	Low	
Activity data					
Total Municipal Solid Waste (MSWT)	Country	-	-30%	+30%	2006 IPCC GL, vol.5, Table 3.5
Total uncertainty of waste composition	Country	-	-30%	+30%	
Uncertainty based on activity data			±42.43%		
Emission factors					
Degradable organic carbon (DOC)	Default	-	-30%	+30%	2006 IPCC GL, vol.5, Table 3.5
Fraction of degradable organic carbon decomposed (DOCf)	Default	-	-20%	+20%	
Methane correction factor (MCF)	Default	1	-10%	0%	
		0.8	-20%	+20%	
		0.5	-20%	+20%	
		0.4	-30%	+30%	
		0.6	-50%	+60%	
Oxidation factor (OX)	Default	0.1	-10%	+10%	
Fraction of CH4 in generated landfill gas (F)	Country	0.55	-5%	+5%	
Methane recovery (R)	Country	-	-50%	+50%	
Uncertainty based on emission factor			±71.67%		
Combined uncertainty: solid waste disposal (5A)			±83.29%		

Time-series Consistency

To achieve time-series consistency in the activity data, e.g. solid waste amount and composition, the relevant agencies, i.e. BMA, DLO, PCD, use standardized methods for data collection across all years, ensuring that definitions, classifications, and methodologies remain consistent. In addition, the handbooks for practical tasks are provided and distributed to local staffs together with periodic training to ensure that each data point is comparable to previous years. The data given in the Thailand Solid Waste Management Information System and National MSW Annual Report of the PCD are used as activity data consistently throughout the time-series. The same emission factors are used throughout the time series.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials.

Category-specific Planned Improvements

Emissions estimated for solid waste disposal (5A) follow the Tier 2 approach. Although activity data, e.g. solid waste amount and composition, are collected nationwide, some IPCC default parameters and emission factors are still used. Therefore, capacity building and support are needed to obtain country-specific parameters, e.g. rate constant (k), DOCs, OX, MCF, for more accurate results.

Estimated Emissions from Solid Waste Disposal (5A)

The estimation of greenhouse gas emissions from the solid waste disposal sector, as shown in Table 2-154 and Figure2-71, distinguishes between well-managed waste disposal sites (sanitary landfills) and poorly managed sites (control dumps and open dumps) from 2000 to 2018. The results show a continuous increase in emissions due to the rising volume of waste in the SWDS. In 2019, the reported methane recovery increased, leading to a reduction in emissions. However, emissions increased again in 2020 as the volume of recovered community waste decreased, and improperly disposed waste increased. A survey of waste composition revealed an increase in single-use plastics due to changes in consumer behavior, such as higher use of online shopping and food delivery services, consistent with Thailand's waste disposal situation report. In 2022, the volume of properly disposed waste increased compared to 2020, but waste recycling decreased due to the global economic downturn caused by the COVID-19 pandemic, which reduced demand for recycled products in the manufacturing sector.

Table 2-154: Emissions in solid waste disposal (5A) for 2020-2022

Year	GHG emission (ktCO_2eq)		
	4A1 Managed Waste Disposal Sites	4A2 Unmanaged Waste Disposal Sites	Total
2000	2,789.71	1,071.59	3,861.31
2001	3,275.64	1,063.77	4,339.41
2002	3,702.96	1,074.30	4,777.25
2003	4,084.37	1,107.67	5,192.04
2004	4,379.87	1,156.03	5,535.90
2005	4,652.51	1,245.15	5,897.67
2006	4,805.41	1,375.76	6,181.17
2007	4,863.66	1,419.16	6,282.83
2008	4,983.14	1,471.97	6,455.12
2009	5,008.75	1,555.18	6,563.92
2010	4,689.38	1,662.14	6,351.52
2011	4,851.65	1,784.50	6,636.14
2012	4,954.04	1,959.85	6,913.89
2013	5,096.71	2,260.08	7,356.79
2014	4,818.19	3,286.28	8,104.48
2015	5,176.43	3,657.24	8,833.67
2016	5,459.17	3,657.31	9,116.49
2017	5,853.33	3,596.55	9,449.89
2018	6,281.49	3,546.14	9,827.63
2019	5,641.25	3,703.25	9,344.51
2020	4,541.82	5,104.76	9,646.58
2021	5,560.37	3,795.45	9,355.82
2022	6,386.24	3,602.58	9,988.81

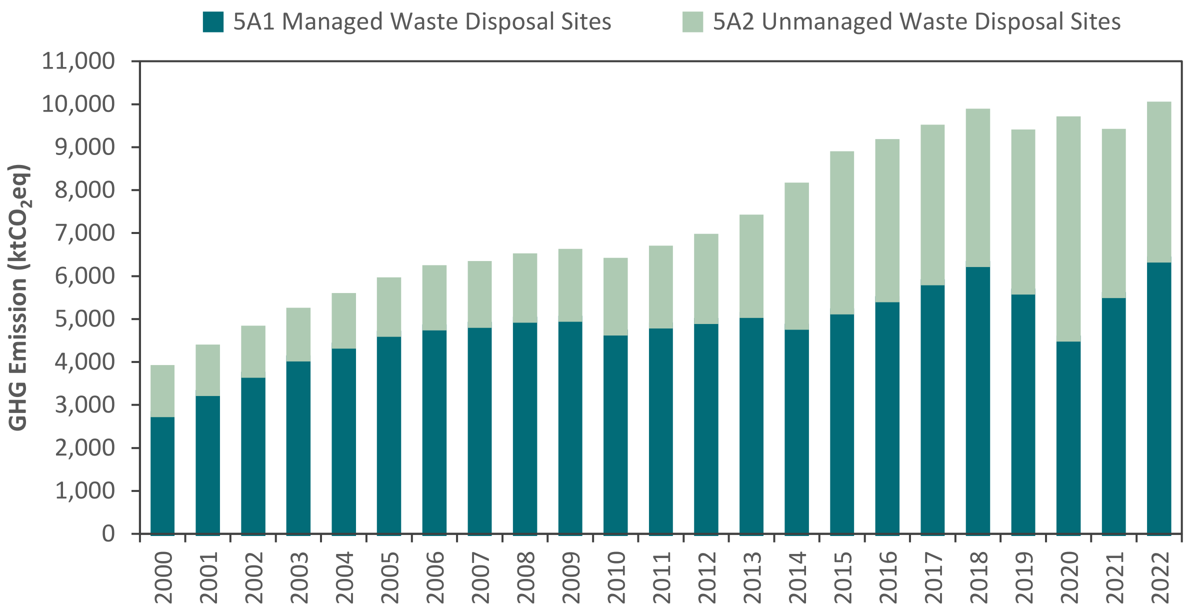


Figure 2-71: Emissions in solid waste disposal (5A) for 2020-2022

Biological Treatment of Solid Waste (5B)

Category Description

The greenhouse gas emissions from the biological treatment of solid waste involve the decomposition of organic materials by naturally occurring microorganisms, including composting, anaerobic digestion (AD), and mechanical-biological treatment (MBT). These methods generate methane (CH_4) and nitrous oxide (N_2O). Biological treatment helps reduce waste volumes, stabilize waste, eliminate pathogens, and produce biogas. The residual materials can be used as soil amendments or fertilizers, or sent for disposal in landfills.

Estimation Method

The CH_4 and N_2O emissions of biological treatment can be estimated using the default method given in Eqs. 5-8 and 5-9 (refer to Eqs. 4.1 and 4.2, respectively, from the 2006 IPCC guidelines vol.5) shown below:

- ***Methane (CH_4) emissions from biological waste treatment***

$$\mathrm{CH_4\ Emissions} = \left[\sum_i (M_i \cdot EF_i) \cdot 10^{-3}\right] - R \qquad (5\text{-}8)$$

Where:

CH_4 Emissions = total CH_4 emissions in inventory year (Gg CH_4)

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

EFi = emission factor for treatment i (g CH_4/kg waste treated)

i = composting or anaerobic digestion or MBT

R = total amount of CH_4 recovered in inventory year (Gg CH_4)

10^{-3} = conversion factor from g to kg

- ***Nitrous oxide (N_2O) emissions from biological waste treatment***

$$N_2O\ Emissions = \sum_i (M_i \cdot EF_i) \cdot 10^{-3} \quad (5\text{-}9)$$

Where:

N_2O Emissions = total N_2O emissions in inventory year (Gg N_2O)

M_i = mass of organic waste treated by biological treatment type i (Gg)

EF_i = emission factor for treatment i (g N_2O/kg waste treated)

i = composting or anaerobic digestion or MBT

10^{-3} = conversion factor from g to kg

Activity Data of Biological Treatment of Solid Waste (5B)

Activity data for greenhouse gas accounting from biological waste treatment include the quantity of organic solid waste treated by composting, anaerobic digestion, and mechanical-biological treatment, and methane recovery. Data are provided by four agencies: PCD, Department of Local Administration, BMA, and DEDE. The amounts of solid waste treated biologically in the years 2020-2022 are shown in Table 2-155.

Table 2-155: Activity data of biological treatment of solid waste (5B)

Type of Biological Treatment	Annual waste at the SWDS (kt)		
	2020	2021	2022
Composting	595.68	768.88	677.29
Anaerobic digestion	40.15	29.20	0.00
Mechanical-biological treatment (MBT)	744.87	1,173.62	1,036.75
Total amount of waste (kt)	1,380.70	1,971.70	1,714.04

Emission Factors of Biological Treatment of Solid Waste (5B)

The emission factors for greenhouse gas calculations follow the recommendations in the 2006 IPCC Guidelines, as listed in Table 2-156.

Table 2-156: Emission factors of biological treatment of solid waste (5B)

Type of Biological Treatment	Emission factor for CH_4 (g CH_4 /kg waste treated)	Emission factor for N_2O (g N_2O/kg waste treated)	Reference
Composting	4	0.24	2006 IPCC GLs
Anaerobic Digestion	0.8	-	
Mechanical-biological treatment (MBT)	0.6	0.24	

Uncertainties

The uncertainty analysis of greenhouse gas emissions calculations from the biological treatment of solid waste (5B) is divided into two parts:

- uncertainty analysis associated with Activity Data (AD), which includes the amount of waste treated biologically, using default values from the 2006 IPCC Guidelines, with an uncertainty of ±30.00%.

- uncertainty analysis associated with Emission Factor (EF) for CH_4 and N_2O, which is set at an uncertainty range of ±100.00%.

When calculating the combined uncertainty for the biological waste treatment (5B), the resulting value of uncertainty is ±104.40%, as shown in Table 2-157.

Table 2-157: Uncertainty analysis of biological treatment of solid waste (5B)

Parameters	Data source	value	Uncertainty Range		Reference
			High	Low	
Activity data					
Total amount of solid waste	Country	-	-30%	+30%	2006 IPCC GL
Uncertainty based on activity data			±30.00%		
Emission factors					
Emission factors for CH_4 and N_2O	Default	0.1	-100%	+100%	2006 IPCC GL
Uncertainty based on emission factor			±100.00%		
Combined uncertainty: Biological treatment of solid waste (5B)			±104.40%		

Time-series Consistency

To achieve time-series consistency in the activity data, e.g. solid waste amount and composition, the relevant agencies, i.e. BMA, DLO, PCD, use standardized methods for data collection across all years, ensuring that definitions, classifications, and methodologies remain consistent. In addition, the handbooks for practical tasks are provided and distributed to local staffs together with periodic training to ensure that each data point is comparable to previous years. The data given in the Thailand Solid Waste Management Information System and National MSW Annual Report of the PCD are used as activity data consistently throughout the time-series. The same emission factors are used throughout the time series.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials.

Category-specific Planned Improvements

Emissions estimated for biological treatment of solid waste (5B) follow the Tier 1 approach. Therefore, capacity building and supports are needed to obtain country-specific emission factors for more accurate results.

Estimated Emissions from Biological Treatment of Solid Waste (5B)

The results shown in Table 2-158 and Figure 2-72 reveal that greenhouse gas emissions from biological treatment of solid waste, including methane (CH_4) and nitrous oxide (N_2O), increased between 2000 and 2022. This increase is driven by higher volumes of waste entering the biological treatment system, in line with the national solid waste management plan (2016-2021), which promotes waste separation at the source and the use of waste for beneficial purposes, such as composting.

Table 2-158: Emissions in biological treatment of solid waste (5B) for 2020-2022

Year	GHG emission (ktCO$_2$eq)		
	CH_4	N_2O	Total
2000	0.14	0.54	0.68
2001	0.14	0.55	0.69
2002	0.15	0.55	0.70
2003	0.15	0.56	0.70
2004	0.15	0.57	0.73
2005	0.15	0.58	0.73
2006	35.84	20.58	56.42
2007	45.33	25.98	71.31
2008	44.27	25.40	69.68
2009	43.67	25.09	68.75
2010	19.06	11.12	30.18
2011	17.10	10.03	27.13
2012	51.15	29.46	80.60
2013	50.97	29.54	80.51
2014	45.08	31.26	76.34
2015	56.13	38.68	94.81
2016	45.01	33.37	78.38
2017	60.90	47.26	108.16
2018	68.41	45.96	114.37
2019	80.99	72.73	153.72
2020	80.13	85.26	165.39
2021	106.49	123.54	230.03
2022	93.27	109.01	202.29

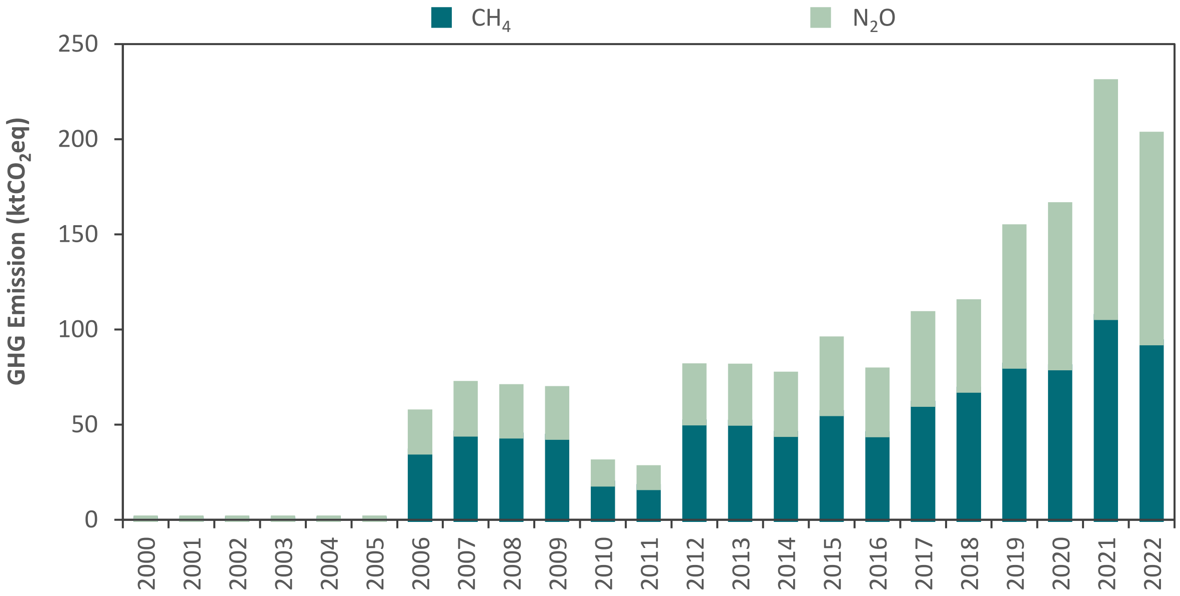


Figure 2-72: Emissions in biological treatment of solid waste (5B) for 2000-2022

Waste Incineration and Open Burning (5C)

Category Description

Waste incineration and open burning are categorized into two sub-sectors: Waste Incineration (5C1) and Open Burning (5C2). These methods generate carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Emission estimates depend on waste type, quantity, composition, organic and fossil carbon content, incineration technology, and operation. Waste is categorized into municipal solid waste, industrial waste, fossil liquid waste, clinical waste, and sewage sludge. Only incineration (5C1) is considered for greenhouse gas emission calculations here. The waste processed in the incineration system is classified into municipal solid waste, industrial waste, clinical waste, and sludge from wastewater treatment systems.

Estimation Method

The CO_2, CH_4, and N_2O emissions of waste incineration can be estimated using the default method given by the 2006 IPCC guidelines, as shown below:

1) Calculation methods for CO_2 emission from waste incineration

The calculation of the CO_2 emissions is based on an estimate of the amount of waste (wet weight) incinerated or open-burned taking into account the dry matter content, the total carbon content, the fraction of fossil carbon and the oxidation factor. The method based on the total amount of waste combusted is outlined in Eq. 5-10 (refer to Eq. 5.1 from the 2006 IPCC guidelines vol.5), and the method based on the MSW composition is given in Eq.11 (refer to Eq. 5.2 from the 2006 IPCC guidelines). It is preferable to apply Eq. 5-11 for MSW, but if the required MSW data are not available, Eq. 10 should be used instead.

- ***CO_2 emission estimate based on the total amount of waste combusted***

$$CO_2 \text{ Emissions} = \sum_i (SW_i \cdot dm_i \cdot CF_i \cdot FCF_i \cdot OF_i) \cdot 44/12 \qquad (5\text{-}10)$$

Where:

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

MSW: municipal solid waste (if not estimated based on composition),
ISW: industrial solid waste, SS: sewage sludge, HW: hazardous waste,
CW: clinical waste, others (that must be specified)

- ***CO_2 emission estimate based on the MSW composition***

$$CO_2 \text{ Emissions} = MSW \sum_j (WF_j \cdot dm_j \cdot CF_j \cdot FCF_j \cdot OF_j) \cdot 44/12 \qquad (5\text{-}11)$$

Where:

CO_2 Emissions	=	CO_2 emissions in inventory year (Gg/yr)
MSW	=	total amount of municipal solid waste as wet weight incinerated (Gg/yr)
WFj	=	fraction of waste type/material of component j in the MSW (as wet weight incinerated)
dmj	=	dry matter content in the component j of the MSW incinerated (fraction)
CFj	=	fraction of carbon in the dry matter of component j
FCFj	=	fraction of fossil carbon in the total carbon of component j
OFj	=	oxidation factor (fraction)
44/12	=	conversion factor from C to CO_2
j	=	component of the MSW incinerated such as paper/cardboard, textiles, food waste, wood, garden (yard) and park waste, disposable nappies, rubber and leather, plastics, metal, glass, other inert waste.

- ***Calculation methods for CH_4 emission from waste incineration***

CH_4 emissions from incineration of waste are a result of incomplete combustion. Important factors affecting the emissions are temperature, residence time, and air ratio (i.e., air volume in relation to the waste amount). The conditions can vary considerably, as waste is a very heterogeneous and low-quality fuel with variations in its calorific value.

CH_4 emission based on the total amount of waste combusted is estimated using Eq. 5-12 (refer to Eq. 5.4 from the 2006 IPCC guidelines vol.5).

$$CH_4 \text{ Emissions} = \sum_i (IW_i \cdot EF_i) \cdot 10^{-6} \quad (5\text{-}12)$$

Where:

CH_4 Emissions	= CH_4 emissions in inventory year (Gg/yr)
IW_i	= amount of solid waste of type i incinerated (Gg/yr)
EF_i	= aggregate CH_4 emission factor (kg CH_4/Gg of waste)
10^{-6}	= conversion factor from kg to Gg
i	= category or type of waste incinerated, specified as follows:

MSW: municipal solid waste, ISW: industrial solid waste, HW: hazardous waste, CW: clinical waste, SS: sewage sludge

- **Calculation methods for N_2O emission from waste incineration**

Nitrous oxide is emitted in combustion processes at relatively low combustion temperatures between 500 and 950 °C. Other important factors affecting the emissions are the type of air pollution control device, type and nitrogen content of the waste and the fraction of excess air N_2O emissions from the combustion of fossil liquid waste can be considered negligible, unless country-specific data indicate otherwise.

N_2O emission based on the waste input to the incinerators is estimated by Eq.5-13 (refer to Eq. 5.5 from the 2006 IPCC guidelines vol.5).

$$N_2O \text{ Emissions} = \sum_i (IW_i \cdot EF_i) \cdot 10^{-6} \quad (5\text{-}13)$$

Where:

N_2O Emissions	= N_2O emissions in inventory year (Gg/yr)
IW_i	= amount of incinerated waste of type i (Gg/yr)
EF_i	= N_2O emission factor (kg N_2O/Gg of waste) for waste of type i
10^{-6}	= conversion from kg to Gg
i	= category or type of waste incinerated, specified as follows:

MSW: municipal solid waste, ISW: industrial solid waste, HW: hazardous waste, CW: clinical waste, SS: sewage sludge

Activity Data of Waste Incineration (5C1)

Activity data for greenhouse gas accounting from waste incineration include the quantity of municipal solid waste, industrial solid waste, clinical waste, and sewage sludge delivered for disposal by incineration. Data are provided by four agencies: the PCD, the Department of Health (DOH), the Department of Industrial Works (DIW), and the BMA. The amounts of waste incinerated for 2020-2022 are shown in Table 2-159.

Table 2-159: Activity data of waste incineration (5C1) for 2020-2022

Type of waste incinerated	Annual waste at the SWDS (kt)		
	2020	2021	2022
Municipal solid waste	117.97	99.62	105.16
Industrial waste	80.28	74.94	45.77
Clinical waste	49.42	89.81	74.12
Sewage sludge	0.50	0.60	1.12
Fossil liquid waste	0.28	0.27	0.43

Emission Factors of Waste Incineration (5C1)

Parameters and emission factors for use in estimation of greenhouse gas emission from waste incineration (5C1) follow the 2006 IPCC guidelines, as detailed in Table 2-160 and Table 2-161, respectively.

Table 2-160: Parameters of waste incineration (5C1)

Parameters	Unit	Waste composition		value	Reference
Oxidation factor (OF)	fraction	MSW		1	2006 IPCC guidelines
		Industrial waste		1	
		Clinical waste		1	
		Sewage sludge		1	
Waste composition of MSW	Unit	Parameters			Reference
		Dry matter content (dm)	Carbon content (CFi)	Fossil carbon (FCFi)	
Food	fraction	0.40	0.38	0.00	2006 IPCC guidelines
Paper		0.90	0.46	0.01	
Garden waste		0.40	0.49	0.00	
Wood		0.85	0.50	0.00	
Other		0.90	0.03	1.00	
Textiles		0.80	0.50	0.20	
Sludge		0.00	0.00	0.00	
Nappies		0.40	0.70	0.10	
Rubber/Leather		0.84	0.67	0.20	
Plastic		1.00	0.75	1.00	
Glass		1.00	0.00	0.00	

Table 2-161: Emission factors of waste incineration (5C1)

Type of waste incinerated	Mode of operation	Type of Incineration	Emission factor		Reference
			CH_4 (kg CH_4 /Gg wet wt)	N_2O (kg N_2O/ Gg wet wt)	
MSW	Continuous	Stoker	0.2	50	2006 IPCC guidelines
		Fluidized bed	0		
	Semi-continuous	Stoker	6	50	
		Fluidized bed	188		
	Batch type	Stoker	60	60	
		Fluidized bed	237		
Industrial waste	n/a	n/a	300	100	
Clinical waste	n/a	n/a	0.2	47	
Sewage sludge	n/a	n/a	9.7	900	

Uncertainties

The uncertainty analysis of greenhouse gas emissions calculations from the waste incineration (5C1) is divided into two parts:

- uncertainty of Activity Data, which includes the amount of MSW and waste materials entering the incinerator. This analysis uses the default values from the 2006 IPCC Guidelines, with an uncertainty of ±5.00%.

- uncertainty of Emission Factors, which includes the dry matter content in solid waste and various parameters related to waste composition, such as the carbon fraction of dry content of waste (CF), the fraction of fossil carbon in the total carbon of component (FCF), combustion efficiency, and emission factors for CH_4, N_2O, and CO_2 from incineration. The overall uncertainty of emission factors is ±118.74%.

When calculating the combined uncertainty for the waste incineration (5C1), the resulting value is ±118.85%, as shown in Table 2-162.

Table 2-162: Uncertainty analysis of waste incineration (5C1)

Parameters	Data source	value	Uncertainty Range		Reference
			High	Low	
Activity data					
Total amount of solid waste incinerated	Country	-	-5%	+5%	2006 IPCC GL
Uncertainty based on activity data			±5.00%		
Emission factors					
Dry matter content in the waste incinerated	Default	-	-50%	+50%	2006 IPCC GL
Parameters of waste component	Default	-	-40%	+40%	
Emission factors of waste incineration for CH_4, N_2O, and CO_2	Default	-	-100%	+100%	
Uncertainty based on emission factor			±118.74%		
Combined uncertainty: Waste incineration (5C1)			±118.85%		

Time-series Consistency

To achieve time-series consistency in the activity data, the relevant agencies, i.e. BMA, DLO, PCD, DIW, and DOH, use standardized methods for data collection across all years, ensuring that definitions, classifications, and methodologies remain consistent. In addition, the handbooks for practical tasks are provided and distributed to local staffs together with periodic training to ensure that each data point is comparable to previous years. The same emission factors are used throughout the time series.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials.

Category-specific Planned Improvements

Emissions estimated for waste incineration (5C1) follow the Tier 1 approach. Therefore, capacity building and support are needed to obtain country-specific parameters and emission factors for more accurate results.

Estimated Emissions from Waste Incineration and Open Burning (5C)

Greenhouse gas emissions from waste incineration, including methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2), decreased between 2018 and 2019 as the volume of waste incinerated decreased, reflecting increased waste separation and reuse. However, emissions rose again between 2020 and 2021 due to increased volumes of clinical waste entering incinerators, as shown in Table 2-163 and Figure 2-73.

Table 2-163: Emissions in waste incineration and open burning (5C) for 2020-2022

Year	GHG emission ($ktCO_2eq$)			
	CO_2	CH_4	N_2O	Total
2000	20.27	0.00	0.52	20.80
2001	20.97	0.00	0.55	21.52
2002	22.68	0.00	0.60	23.28
2003	23.63	0.00	0.63	24.26
2004	23.25	0.00	0.61	23.86
2005	23.40	0.00	0.61	24.01
2006	33.46	0.00	0.86	34.32
2007	40.91	0.00	1.07	41.99
2008	43.90	0.00	1.13	45.04
2009	27.80	0.01	0.68	28.49
2010	25.89	0.01	0.65	26.54
2011	110.53	0.06	2.24	112.83
2012	95.03	0.05	1.96	97.04
2013	141.97	0.07	2.86	144.90
2014	173.57	0.09	12.42	186.08
2015	198.27	0.09	8.58	206.95
2016	233.99	0.10	9.01	243.10
2017	197.53	0.09	5.90	203.52
2018	175.84	0.08	4.11	180.03
2019	159.86	0.07	4.16	164.09
2020	191.04	0.69	4.42	196.16
2021	218.39	0.65	4.57	223.60
2022	175.49	0.40	3.80	179.69

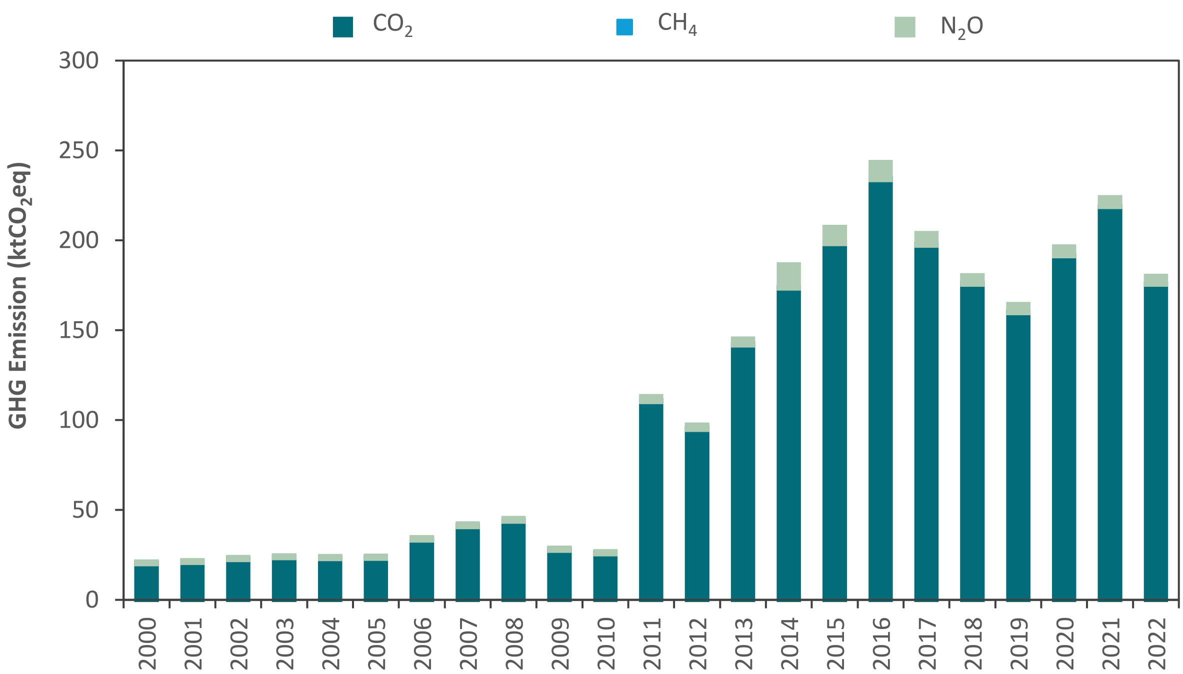


Figure 2-73: Emissions in waste incineration and open burning (5C) for 2020-2022

Wastewater Treatment and Discharge (5D)

Domestic Wastewater Treatment and Discharge (5D1)

Category Description

Wastewater is a source of methane (CH_4) when treated or disposed of under anaerobic conditions, and it can also emit nitrous oxide (N_2O). Carbon dioxide (CO_2) emissions from wastewater are not included in greenhouse gas inventories due to their biogenic origin. Wastewater originates from a variety of domestic, commercial, and industrial sources and may be treated on-site (uncollected), conveyed to a centralized treatment plant (collected), or discharged untreated either nearby or through an outfall. The extent of CH_4 production is mainly influenced by the amount of degradable organic material present, the temperature, and the type of treatment system used. Treatment systems or discharge methods that create anaerobic conditions generally produce CH_4, while systems that maintain aerobic conditions typically produce little to no CH_4.

Nitrous oxide (N_2O) emissions can occur as direct emissions from treatment plants or from indirect emissions from wastewater after discharge of effluent into waterways, lakes or the sea. Direct emissions from nitrification and denitrification at wastewater treatment plants may be considered as a minor source.

Estimation Method

According to the 2006 IPCC guidelines, methods for estimation of CH_4 and N_2O emissions from domestic wastewater treatment and discharge are described as follows:

1) CH_4 emissions from wastewater

- Total Organics in Wastewater (TOW):

TOW represents total amount of the degradable organic content in domestic wastewater. This parameter is a function of human population and BOD generation per person. It is expressed in terms of biochemical oxygen demand (kg BOD/year), as shown in Eq. 5-14 (refer to Eq. 6.3 from 2006 IPCC guidelines vol.5).

$$TOW = P \cdot BOD \cdot 0.001 \cdot I \cdot 365 \quad (5\text{-}14)$$

Where:

TOW = total organics in wastewater in inventory year (kg BOD/yr)

P = country population in inventory year (person)

BOD = country-specific per capita BOD in inventory year (g/person/day)

0.001 = conversion from g BOD to kg BOD

I = correction factor for additional industrial BOD discharged into sewers (for collected the default is 1.25, for uncollected the default is 1.00)

- CH_4 emission factor for each domestic wastewater treatment/discharge pathway

The emission factor for a wastewater treatment and discharge pathway and system is a function of the maximum CH_4 producing potential (Bo) and the methane correction factor (MCF) for the wastewater treatment and discharge system, as shown in Eq. 5-15 (refer to Eq. 6.2 from 2006 IPCC guidelines vol 5).

$$EF_j = B_0 \cdot MCF_j \tag{5-15}$$

Where:

- EF_j = emission factor (kg CH_4/kg BOD)
- j = each treatment/discharge pathway or system
- B_o = maximum CH_4 producing capacity (kg CH_4/kg BOD)
- MCF_j = methane correction factor (fraction)

- Total CH_4 emissions from domestic wastewater

Total CH_4 emissions from domestic wastewater are estimated by Eq. 5-16 (refer to Eq. 6.1 in 2006 IPCC guidelines vol.5).

$$CH_4\ Emissions = \sum_{i,j} \left(U_i \cdot T_{i,j} \cdot EF_j\right) \cdot (TOW - S) - R \tag{5-16}$$

Where:

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

2) N_2O emissions from wastewater

To calculate indirect N_2O emissions from wastewater treatment effluent that is discharged into aquatic environments, the 2006 IPCC Guidelines use activity data that includes nitrogen levels in treated wastewater discharged into natural water bodies, national population, and annual protein consumption. Steps for estimation of N_2O emissions from domestic wastewater treatment and discharge are described as follows:

- Total nitrogen in wastewater discharge

The total nitrogen in the effluent is estimated by Eq. 5-17 (referencing Equation 6.8 from IPCC 2006).

$$N_{eff} = (P \cdot Protein \cdot F_{NPR} \cdot F_{Non-Con} \cdot F_{Ind-Com}) - N_{Sludge} \quad (5\text{-}17)$$

Where:

N_{eff}	= total annual amount of nitrogen in the wastewater effluent, kg N/yr
P	= human population
Protein	= annual per capita protein consumption, kg/person/yr
F_{NPR}	= fraction of nitrogen in protein, default = 0.16, kg N/kg protein
$F_{Non-Con}$	= factor for non-consumed protein added to the wastewater
$F_{Ind-Com}$	= factor for industrial and commercial co-discharged protein into the sewer system
N_{Sludge}	= nitrogen removed with sludge (default = zero), kg N/yr

- N_2O emissions from wastewater effluent

Indirect N_2O emissions from wastewater treatment effluent that is discharged into aquatic environments are estimated by Eq. 5-18 (referencing Equation 6.7 from IPCC 2006).

$$N_2O\ Emissions = N_{eff} . EF_{eff} . {}^{44}/_{28} \quad (5\text{-}18)$$

Where:

N_2O emissions	=	N_2O emissions in inventory year (kg N_2O/yr)
N_{eff}	=	nitrogen in the effluent discharged to aquatic environments (kg N/yr)
EF_{eff}	=	emission factor for N_2O emissions from discharged to wastewater (kg N_2O-N/kg N)
44/28	=	conversion factor of kg N_2O-N into kg N_2O.

Activity Data of Domestic Wastewater Treatment and Discharge (5D1)

Activity data for estimating greenhouse gas emissions from domestic wastewater treatment and discharge (5D1) includes the population generating wastewater, categorized by urban (municipal city, town, and subdistrict areas) and rural populations (out of subdistrict area), as shown in Table 2-164. Additional data includes the wastewater generation and the organic content (BOD) in wastewater, as shown in Table 2-165, along with types of wastewater treatment systems, and fraction of treatment or discharge pathway, as shown in Table 2-166. Besides, annual protein consumption data is drawn from national food and nutrition surveys conducted by the DOH and the Health Systems Research Institute, as shown in Table 2-167. This data is collected by four key agencies: the PCD, the BMA, the Wastewater Management Authority (WMA), and the DOH.

Emission Factors of Domestic Wastewater Treatment and Discharge (5D1)

Parameters and emission factors for use in estimation of greenhouse gas emission from wastewater treatment and discharge follow the 2006 IPCC Guidelines, as listed in Table 2-168.

Table 2-164: Population generating wastewater, categorized by location for 2020-2022

Location		Year		
		2020	2021	2022
Bangkok	Urban area	5,588,222	5,527,994	5,494,932
	Rural area	0	0	0
Central Thailand (excluding Bangkok)	Urban area	6,799,528	6,780,389	6,774,028
	Rural area	10,455,577	10,273,412	10,304,804
Northern Thailand	Urban area	3,250,971	3,235,622	3,214,124
	Rural area	8,776,300	8,774,402	8,763,772
Northeastern Thailand	Urban area	4,443,710	4,443,226	4,413,303
	Rural area	17,404,518	17,644,127	17,628,521
Southern Thailand	Urban area	2,728,900	2,727,080	2,714,435
	Rural area	6,739,001	6,765,187	6,782,556
Overall Thailand	Urban area	22,811,331	22,714,311	22,610,822
	Rural area	43,375,396	43,457,128	43,479,653
Total Population		**66,186,727**	**66,171,439**	**66,090,475**

Table 2-165: Domestic wastewater generation and organic loading for 2020-2022

Location		Wastewater generation rate (m^3/cap-d)			Organic loading (kg BOD/L)
		2020	2021	2022	
Bangkok	Urban area	360.53	345.00	349.35	0.00012
	Rural area	n/a	n/a	n/a	0.00012
Central Thailand (excluding Bangkok)	Urban area	150.00	150.00	150.00	0.00012
	Rural area	150.00	150.00	150.00	0.00012
Northern Thailand	Urban area	150.00	150.00	150.00	0.00012
	Rural area	150.00	150.00	150.00	0.00012
Northeastern Thailand	Urban area	150.00	150.00	150.00	0.00012
	Rural area	150.00	150.00	150.00	0.00012
Southern Thailand	Urban area	150.00	150.00	150.00	0.00012
	Rural area	150.00	150.00	150.00	0.00012

Table 2-166: Fraction of wastewater treated by the handling system by location for 2020-2022

Type of handling system	Fraction of wastewater treated by the handling system in 2020 by location									
	Bangkok		Central (exclude Bangkok)		Northern Thailand		Northeastern Thailand		Southern Thailand	
	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area
Activated sludge	0.444	0.000	0.104	0.001	0.070	0.000	0.000	0.000	0.039	0.003
Rotating biological contactor	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stabilization pond	0.001	0.000	0.068	0.000	0.068	0.000	0.205	0.000	0.199	0.000
Aerated lagoon	0.001	0.000	0.026	0.000	0.074	0.000	0.108	0.000	0.063	0.000
Oxidation ditch	0.001	0.000	0.088	0.000	0.000	0.000	0.000	0.000	0.172	0.000
Constructed wetland	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Sea river and lake discharge	0.002	0.000	0.003	0.004	0.003	0.004	0.003	0.004	0.002	0.004
Septic system	0.531	0.000	0.681	0.959	0.756	0.960	0.658	0.960	0.505	0.957
Latrine	0.020	0.000	0.026	0.036	0.028	0.036	0.025	0.036	0.019	0.036
Trickling Filter	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Type of handling system	Fraction of wastewater treated by the handling system in 2021 by location									
	Bangkok		Central (exclude Bangkok)		Northern Thailand		Northeastern Thailand		Southern Thailand	
	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area
Activated sludge	0.444	0.000	0.140	0.000	0.082	0.000	0.000	0.000	0.032	0.003
Rotating biological contactor	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stabilization pond	0.001	0.000	0.065	0.000	0.071	0.000	0.232	0.000	0.231	0.000
Aerated lagoon	0.001	0.000	0.023	0.000	0.081	0.000	0.125	0.000	0.050	0.000
Oxidation ditch	0.001	0.000	0.092	0.000	0.000	0.000	0.000	0.000	0.162	0.000
Constructed wetland	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Sea river and lake discharge	0.002	0.000	0.003	0.004	0.003	0.004	0.003	0.004	0.002	0.004
Septic system	0.532	0.000	0.647	0.960	0.735	0.960	0.617	0.960	0.503	0.957
Latrine	0.020	0.000	0.024	0.036	0.028	0.036	0.023	0.036	0.019	0.036
Trickling Filter	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Type of handling system	Fraction of wastewater treated by the handling system in 2022 by location									
	Bangkok		Central (exclude Bangkok)		Northern Thailand		Northeastern Thailand		Southern Thailand	
	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area
Activated sludge	0.459	0.000	0.111	0.001	0.070	0.000	0.000	0.000	0.029	0.004
Rotating biological contactor	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stabilization pond	0.001	0.000	0.052	0.000	0.070	0.000	0.179	0.000	0.190	0.000
Aerated lagoon	0.001	0.000	0.024	0.000	0.086	0.000	0.130	0.000	0.055	0.000
Oxidation ditch	0.001	0.000	0.088	0.000	0.000	0.000	0.000	0.000	0.178	0.000
Constructed wetland	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Sea river and lake discharge	0.002	0.000	0.003	0.004	0.003	0.004	0.003	0.004	0.002	0.004
Septic system	0.517	0.000	0.688	0.959	0.742	0.960	0.663	0.960	0.526	0.956
Latrine	0.019	0.000	0.026	0.036	0.028	0.036	0.025	0.036	0.020	0.036
Trickling Filter	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 2-167: Annual protein consumption for 2020-2022

Parameter	2020	2021	2022
Population	66,186,727	66,171,439	66,090,475
Protein consumption (kg/person/yr)	21.06	21.06	21.06

Table 2-168: Emission factors of domestic wastewater treatment and discharge (5D1)

Parameters	Unit	Item	value	Reference
Maximum CH_4 producing capacity (B_0)	kg CH_4/kg BOD	Domestic wastewater	0.60	2006 IPCC Guidelines
Methane conversion factor (MCF)	Fraction	Untreated - Sea, river and lake discharge	1.0	2006 IPCC Guidelines
		- Aerobic treatment plant (Must be well managed)	0	
		- Aerobic treatment plant (Not well managed)	0.3	
		- Anaerobic digester for sludge	0.8	
		- Anaerobic reactor	0.8	
		- Anaerobic shallow lagoon	0.2	
		- Anaerobic deep lagoon	0.8	
Factor for non-consumed protein added to the wastewater ($F_{Non-con}$)	Fraction	-	1.1	2006 IPCC Guidelines
Factor for industrial and commercial co-discharged protein into the sewer system ($F_{Ind-con}$)	Fraction	-	1.25	2006 IPCC Guidelines
Fraction of N in protein (F_{NPR})	kg N/kg protein	-	0.16	2006 IPCC Guidelines
Nitrogen removed with sludge (N_{sludge})	kg N/yr	-	0	2006 IPCC Guidelines
Emission factor for N_2O emissions discharged to wastewater (EF_{eff})	kg N_2O-N/kg N	-	0.005	2006 IPCC Guidelines

Uncertainties

The uncertainty analysis of greenhouse gas emissions estimation of domestic wastewater treatment and discharge (5D1) is divided into two parts:

uncertainty based on Activity Data, which includes the population size, amount of organic pollution in the form of biochemical oxygen demand (BOD), the proportion of population in municipal (urban) areas and non-municipal (rural) areas. This also considers the income-group distribution of the population and the fraction of treatment methods and discharge. Default values from the 2006 IPCC Guidelines are applied, resulting in an uncertainty of ±60.42%.

uncertainty of Emission Factors, which includes the correction factor for additional industrial BOD discharged into sewers (I), the maximum methane production potential (B_0), and the methane correction factor (MCF) for the treatment or discharge methods. The uncertainty for emission factors is ±42.43%.

When calculating the combined uncertainty for the domestic wastewater treatment and discharge (5D1), the resulting value is ±73.83%, as shown in Table 2-169.

Table 2-169: Uncertainty analysis of domestic wastewater treatment and discharge (5D1)

Parameters	Data source	value	Uncertainty Range		Reference
			High	Low	
Activity data					
Population	Country	-	-5%	+5%	2006 IPCC Guidelines
BOD loading of domestic wastewater	Country	-	-30%	+30%	
Fraction of population in income group (Ui,j)	Country	-	-15%	+15%	
Degree of utilization of treatment/ discharge pathway or system (Ti,j)	Country	-	-50%	+50%	
Uncertainty based on activity data			±60.42%		
Emission factors					
Correction factor for additional industrial BOD discharged into sewers (I)	Default	1.25/1.00	0%	0%	2006 IPCC Guidelines
Maximum CH_4 producing capacity (B_0)	Default	0.6	-30%	+30%	
Methane correction factor (MCF)	Default	-	-30%	+30%	
Uncertainty based on emission factor			±42.43%		
Combined uncertainty: Domestic wastewater treatment and discharge (5D1)			±73.83%		

Time-series Consistency

To achieve time-series consistency in the activity data, the relevant agencies, i.e. BMA, PCD, DLA, and WMA, use standardized methods for data collection across all years, ensuring that definitions, classifications, and methodologies remain consistent. The same emission factors are used throughout the time series.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials.

Category-specific Planned Improvements

Collaborating with research institutions to derive more representative methane (CH_4) and nitrous oxide (N_2O) emission factors. Capacity building for personnel involved in wastewater GHG inventory to enhance their understanding of IPCC guidelines and best practices.

Estimated Emissions from Domestic Wastewater Treatment and Discharge (5D1)

Greenhouse gas emissions from domestic wastewater treatment and discharge (5D1) consist primarily of methane (CH_4) and nitrous oxide (N_2O), with methane contributing the most significantly in this subsector. As shown in Table 2-170 and Figure 2-74, greenhouse gas emissions increased steadily between 2000 and 2013, in line with population growth. However, emissions declined after 2014 due to a reduction in the wastewater generation rate, as revised by the PCD.

Table 2-170: Emissions in domestic wastewater treatment and discharge (5D1) for 2020-2022

Year	GHG emission ($ktCO_2eq$)		
	CH_4	N_2O	Total
2000	2,287.83	524.26	2,812.09
2001	2,438.33	527.90	2,966.23
2002	2,576.09	532.06	3,108.15
2003	2,650.87	534.43	3,185.30
2004	2,661.22	525.06	3,186.28
2005	2,742.77	528.82	3,271.59
2006	2,826.88	539.01	3,365.89
2007	2,883.35	547.54	3,430.89
2008	2,978.95	557.36	3,536.31
2009	3,020.91	565.33	3,586.24
2010	3,095.91	575.29	3,671.20
2011	3,169.01	583.91	3,752.92
2012	3,265.62	594.27	3,859.88
2013	3,333.88	604.22	3,938.10
2014	2,115.83	614.33	2,730.16
2015	2,116.16	627.05	2,743.22
2016	2,118.02	636.02	2,754.04
2017	2,100.82	638.50	2,739.32
2018	2,102.42	640.68	2,743.10
2019	2,148.33	640.64	2,788.97
2020	2,090.12	638.48	2,728.60
2021	2,067.55	638.34	2,705.89
2022	2,070.27	637.56	2,707.83

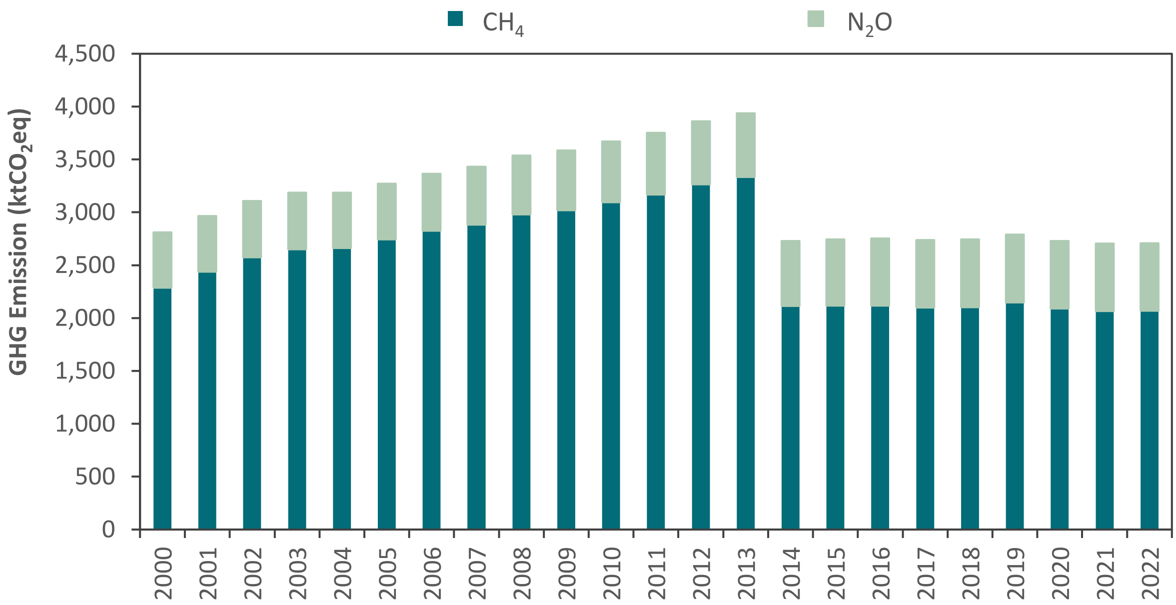


Figure 2-74: Emissions in domestic wastewater treatment and discharge (5D1) for 2020-2022

Industrial Wastewater Treatment and Discharge (5D2)

Category Description

The assessment of greenhouse gas emissions from industrial wastewater treatment and discharge primarily considers methane (CH_4) emissions, which result from the breakdown of organic matter, represented as chemical oxygen demand (COD), in wastewater from industrial production. Wastewater collected from various industries undergoes biological treatment in either aerobic or anaerobic systems, which affects CH_4 production levels; anaerobic conditions lead to greater CH_4 emissions than aerobic treatment.

CH_4 emissions from industrial wastewater are based on the concentration of organics in the wastewater, volume, and treatment methods specific to each industry type. The industries that primarily emit methane include food processing, pulp and paper, alcohol production, and palm oil processing. Methane captured for electricity or heat generation is subtracted from total CH_4 emissions, reducing net emissions from industrial wastewater treatment and discharge.

Estimation Method

According to the 2006 IPCC Guidelines, steps for estimation of methane emissions from industrial wastewater treatment and discharge (5D2) are described as follows:

- Total Organics in Wastewater (TOW)

TOW represents total amount of the degradable organic content in industrial wastewater. Total organically degradable carbon in wastewater (TOW) for industrial sector I is a function of total industrial products for the sector, amount of wastewater generated per ton of product, and COD of those wastewaters. It is expressed in terms of chemical oxygen demand (kg COD/year), as shown in Eq. 5-19 (refer to Eq. 6.6 from 2006 IPCC guidelines).

$$\mathrm{TOW}_i = \mathrm{P}_i \cdot \mathrm{W}_i \cdot \mathrm{COD}_i \qquad (5\text{-}19)$$

Where:

TOW_i	=	total organically degradable material in wastewater for industry *i* (kg COD/yr)
i	=	industrial sector
P_i	=	total industrial product for industrial sector (t/yr)
W_i	=	wastewater generated (m^3/t product)
COD_i	=	chemical oxygen demand (industrial degradable organic component in wastewater) (kg COD/m^3)

- CH_4 emission factor for each industrial wastewater treatment/discharge pathway

The emission factor for a wastewater treatment and discharge pathway and system is a function of the maximum CH_4 producing potential (Bo) and the methane correction factor (MCF) for the wastewater treatment and discharge system, as shown in Eq. 5-20 (refer to Eq. 6.5 from 2006 IPCC guidelines).

$$EF_j = B_o \times MCF_j \qquad (5\text{-}20)$$

Where:

EF_j	=	emission factor for each treatment/discharge pathway or system ($kg\ CH_4/kg\ COD$)
j	=	each treatment/discharge pathway or system
B_o	=	maximum CH_4 producing capacity ($kg\ CH_4/kg\ COD$)
MCF_j	=	methane correction factor (fraction)

- Total CH_4 emissions from industrial wastewater

Total CH_4 emissions from industrial wastewater are estimated by Eq. 5-21 (refer to Eq. 6.4 in 2006 IPCC guidelines)

$$CH_4\ Emissions\ \ (kg\ CH_4/yr) = \sum_i [(TOW_i - S_i)\ EF_i - R_i] \qquad (5\text{-}21)$$

Where:

CH_4 Emissions	=	CH_4 emissions in inventory year ($kg\ CH_4/yr$)
TOW_i	=	total organically degradable material in wastewater from industry i in inventory year (kg COD/yr)
i	=	industrial sector
S_i	=	organic component removed as sludge in inventory year (kg COD/yr)
EF_i	=	emission factor for industry i ($kg\ CH_4/kg\ COD$) for treatment/ discharge pathway or system(s) used in inventory year
R_i	=	amount of CH_4 recovered in inventory year ($kg\ CH_4/yr$)

Activity Data of Industrial Wastewater Treatment and Discharge (5D2)

The activity data for estimating greenhouse gas emissions from industrial wastewater treatment and discharge (5D2) includes annual production volumes by each industrial sector, organic content in wastewater as chemical oxygen demand (COD) by sector, wastewater generation per ton product by each sector, and methane recovery, as shown in Table 2-171. Additionally, the fraction of treatment/discharge pathways by industrial sector is shown in Table 2-172. These data were collected by three main agencies: the Office of Industrial Economics (OIC), the DIW, and the DEDE, which collected data on methane recovery used for electricity and/or heat generation.

Table 2-171: Activity data of industrial wastewater treatment and discharge (5D2) for 2020-2022

Industrial Sectors	Wastewater generation (m^3/ton product)	Total industrial product (ton/yr)			Organic content (kg COD/m^3)			Methane recovery (kgCH_4/yr)		
		2020	2021	2022	2020	2021	2022	2020	2021	2022
Meat packing	13.00	2,577,576.88	2,555,405.23	3,331,651.00	2.37	2.08	1.73	3,974,006.58	3,974,006.58	
Dairy products	7.00	1,178,811.42	1,123,567.47	1,079,796.00	2.04	2.03	1.87			
Fish processing	12.00	1,056,333.81	956,223.74	1,007,723.00	2.59	2.37	2.44			
Palm oil	3.10	3,691,949.74	4,063,668.15	4,194,640.00	63.05	50.92	52.12	92,592,327.91	130,737,721.00	104,066,820.94
Canneries (Fruit/Juice)	20.00	1,198,346.47	1,198,877.56	1,367,812.00	3.44	3.50	3.30	2,875,107.37	2,875,107.37	8,052,374.03
Starch	12.00	3,049,299.38	3,427,984.69	4,743,502.00	12.15	13.34	10.77	68,821,827.62	102,411,285.30	68,284,768.91
Flour products	2.00	192,652.80	196,242.79	191,976.00	2.15	2.45	2.52	71,353.18	123,774.11	
Sugar	9.00	13,961,279.10	15,201,444.49	34,368,617.29	3.05	5.04	4.69			
Ice cream	6.40	674,658.24	676,307.33	723,855.00	3.34	5.19	4.87			
Seasoning	1.00	111,525.91	115,152.94	106,864.85	2.41	7.67	3.24	200,428.16	200,428.16	
Animal feed	2.70	12,678,784.41	12,925,898.64	17,062,144.00	2.60	3.55	2.49			
Alcohol/Liquor	24.00	320,380.14	328,800.30	544,574.00	71.28	73.84	80.74	17,908,471.08	17,908,471.08	
Ethanol	24.00	457,427.05	359,933.54	1,273,951.00	33.06	37.58	22.35	69,447,879.48	65,642,942.03	136,677,209.55
Wine	23.00	-	-	-	1.80	1.33	1.50			
Beer	6.30	2,119,915.24	2,104,393.85	2,358,923.00	3.22	3.40	3.31	1,024,866.12	1,024,866.12	
Soft drink	20.00	7,491,350.11	7,509,586.32	8,673,965.00	1.55	1.39	1.50	5,998,927.70	5,998,927.70	18,713,398.26
Textile	120.00	251,406.55	159,026.14	254,670.08	1.09	0.92	0.83			
Tannery	18.20	25,885.47	34,586.02	37,150.33	3.46	5.32	3.95			
Paper and pulp	100.00	6,532,005.43	6,764,322.82	6,493,567.00	2.64	2.45	2.45			
Chemical products	6.90	8,561,875.81	9,553,424.29	8,305,107.00	2.98	3.73	3.67			
Petrochemical products	1.20	7,460,449.68	7,874,223.58	7,860,780.00	0.78	0.81	0.66			
Soap and Detergents	2.00	617,404.41	591,982.03	790,164.00	4.37	4.39	4.36			
Petroleum Refining	2.00	48,337.11	47,314.97	2,891,955.73	0.21	0.51	0.54			
Rubber	5.28	1,097,108.54	1,188,847.93	2,928,549.00	1.52	1.12	1.15	209,900.69	192,682.32	

Table 2-172: Fraction of treatment/discharge pathways by industrial sector for 2020-2022

Industrial Sectors	Type of treatment/discharge pathways: 2020															
	Anaerobic covered lagoon	UASB	Anaerobic filter	Anaerobic tank	Anaerobic pond	Anaerobic digester	Septic system	Stabilization pond	Polishing pond	Aerated lagoon	Activated sludge	Constructed wetland	Oxidation ditch	SBR	Storage pond	Sea, river, lake discharge
Meat packing	0.038	0.043	0.004	0.332	0.102	0.000	0.000	0.074	0.063	0.063	0.223	0.000	0.000	0.028	0.000	0.000
Dairy products	0.000	0.000	0.144	0.000	0.008	0.344	0.000	0.000	0.000	0.292	0.135	0.000	0.000	0.076	0.000	0.000
Fish processing	0.019	0.263	0.191	0.000	0.174	0.000	0.000	0.016	0.036	0.008	0.256	0.000	0.000	0.028	0.004	0.000
Palm oil	0.346	0.000	0.000	0.149	0.109	0.000	0.000	0.134	0.136	0.038	0.001	0.000	0.016	0.012	0.017	0.000
Canneries	0.107	0.003	0.265	0.000	0.186	0.000	0.000	0.086	0.004	0.116	0.073	0.000	0.005	0.014	0.063	0.000
Starch	0.425	0.222	0.000	0.000	0.095	0.000	0.000	0.083	0.000	0.007	0.070	0.000	0.063	0.011	0.001	0.000
Flour products	0.000	0.069	0.136	0.000	0.225	0.000	0.000	0.002	0.000	0.000	0.430	0.000	0.000	0.094	0.000	0.000
Sugar	0.004	0.044	0.000	0.000	0.125	0.000	0.000	0.688	0.006	0.054	0.076	0.000	0.002	0.000	0.000	0.000
Ice cream	0.000	0.208	0.318	0.000	0.156	0.000	0.000	0.093	0.000	0.000	0.220	0.000	0.000	0.005	0.000	0.000
Seasoning	0.072	0.545	0.014	0.000	0.028	0.000	0.000	0.080	0.133	0.000	0.129	0.000	0.000	0.000	0.000	0.000
Animal feed	0.549	0.091	0.000	0.000	0.321	0.000	0.000	0.000	0.000	0.001	0.038	0.000	0.000	0.000	0.000	0.000
Alcohol/Liquor	0.147	0.008	0.016	0.001	0.760	0.000	0.000	0.000	0.000	0.001	0.007	0.000	0.000	0.000	0.055	0.000
Ethanol	0.696	0.149	0.000	0.088	0.021	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Wine	0.000	0.000	0.000	0.000	0.672	0.000	0.000	0.000	0.000	0.000	0.036	0.000	0.000	0.292	0.000	0.000
Beer	0.000	0.969	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.031	0.000	0.000	0.000	0.000	0.000
Soft drink	0.021	0.395	0.265	0.000	0.002	0.000	0.000	0.072	0.000	0.017	0.098	0.000	0.000	0.000	0.000	0.000
Textile	0.000	0.005	0.000	0.001	0.105	0.000	0.000	0.007	0.124	0.005	0.579	0.000	0.000	0.000	0.012	0.000
Tannery	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.116	0.000	0.000	0.000	0.000	0.000
Paper and pulp	0.000	0.000	0.000	0.000	0.145	0.000	0.000	0.008	0.000	0.000	0.589	0.000	0.022	0.103	0.000	0.000
Chemical products	0.000	0.413	0.076	0.000	0.000	0.000	0.000	0.010	0.000	0.001	0.405	0.000	0.000	0.019	0.069	0.000
Petrochemical products	0.014	0.000	0.012	0.000	0.007	0.000	0.000	0.000	0.000	0.006	0.841	0.000	0.000	0.023	0.000	0.000
Soap and Detergents	0.000	0.000	0.012	0.000	0.007	0.000	0.000	0.023	0.000	0.000	0.689	0.000	0.000	0.191	0.064	0.000
Petroleum Refining	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.849	0.000	0.000	0.000	0.000	0.000
Rubber	0.044	0.024	0.000	0.000	0.040	0.000	0.000	0.047	0.038	0.221	0.536	0.000	0.003	0.039	0.002	0.000

Table 2-172: Fraction of treatment/discharge pathways by industrial sector for 2020-2022 (cont'd)

Industrial Sectors	Type of treatment/discharge pathways: 2021															
	Anaerobic covered lagoon	UASB	Anaerobic filter	Anaerobic tank	Anaerobic pond	Anaerobic digester	Septic system	Stabilization pond	Polishing pond	Aerated lagoon	Activated sludge	Constructed wetland	Oxidation ditch	SBR	Storage pond	Sea, river, lake discharge
Meat packing	0.163	0.045	0.005	0.282	0.073	0.000	0.000	0.053	0.000	0.081	0.272	0.000	0.000	0.005	0.000	0.000
Dairy products	0.000	0.000	0.086	0.000	0.050	0.000	0.000	0.000	0.000	0.000	0.760	0.000	0.000	0.104	0.000	0.000
Fish processing	0.020	0.229	0.137	0.000	0.140	0.000	0.000	0.016	0.042	0.007	0.332	0.000	0.009	0.060	0.003	0.000
Palm oil	0.862	0.157	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canneries	0.167	0.008	0.274	0.000	0.361	0.000	0.000	0.020	0.005	0.024	0.114	0.000	0.008	0.000	0.000	0.000
Starch	0.726	0.207	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Flour products	0.000	0.279	0.130	0.000	0.234	0.000	0.000	0.009	0.000	0.000	0.221	0.000	0.000	0.104	0.000	0.000
Sugar	0.000	0.118	0.000	0.000	0.044	0.000	0.000	0.801	0.000	0.015	0.022	0.000	0.000	0.000	0.000	0.000
Ice cream	0.000	0.000	0.120	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.880	0.000	0.000	0.000	0.000	0.000
Seasoning	0.036	0.474	0.014	0.000	0.008	0.000	0.000	0.015	0.000	0.000	0.095	0.000	0.000	0.000	0.000	0.000
Animal feed	0.000	0.224	0.078	0.000	0.257	0.000	0.000	0.022	0.000	0.243	0.000	0.000	0.000	0.175	0.000	0.000
Alcohol/Liquor	0.875	0.027	0.098	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ethanol	0.814	0.197	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wine	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Beer	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Soft drink	0.000	0.211	0.352	0.000	0.000	0.000	0.000	0.095	0.000	0.019	0.230	0.000	0.000	0.022	0.000	0.000
Textile	0.000	0.000	0.000	0.002	0.072	0.000	0.000	0.007	0.000	0.253	0.408	0.000	0.000	0.109	0.000	0.000
Tannery	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.543	0.000	0.000	0.438	0.000	0.000
Paper and pulp	0.000	0.000	0.000	0.000	0.048	0.000	0.000	0.044	0.000	0.011	0.826	0.000	0.000	0.072	0.000	0.000
Chemical products	0.000	0.319	0.093	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.534	0.000	0.000	0.001	0.045	0.000
Petrochemical products	0.000	0.000	0.020	0.000	0.014	0.000	0.000	0.000	0.000	0.013	0.848	0.000	0.000	0.012	0.000	0.000
Soap and Detergents	0.000	0.000	0.016	0.000	0.000	0.000	0.000	0.030	0.000	0.000	0.772	0.000	0.000	0.182	0.000	0.000
Petroleum Refining	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.532	0.000	0.421	0.000	0.000	0.000
Rubber	0.079	0.000	0.000	0.000	0.024	0.000	0.000	0.138	0.000	0.215	0.197	0.000	0.008	0.224	0.000	0.000

Table 2-172: Fraction of treatment/discharge pathways by industrial sector for 2020-2022 (cont'd)

Industrial Sectors	Type of treatment/discharge pathways: 2022															
	Anaerobic covered lagoon	UASB	Anaerobic filter	Anaerobic tank	Anaerobic pond	Anaerobic digester	Septic system	Stabilization pond	Polishing pond	Aerated lagoon	Activated sludge	Constructed wetland	Oxidation ditch	SBR	Storage pond	Sea, river, lake discharge
Meat packing	0.114	0.043	0.000	0.249	0.102	0.000	0.000	0.034	0.000	0.099	0.230	0.000	0.000	0.000	0.000	0.000
Dairy products	0.000	0.000	0.198	0.000	0.009	0.000	0.000	0.000	0.000	0.000	0.676	0.000	0.000	0.116	0.000	0.000
Fish processing	0.028	0.171	0.113	0.000	0.131	0.000	0.000	0.016	0.049	0.007	0.311	0.029	0.000	0.097	0.004	0.000
Palm oil	0.143	0.000	0.000	0.553	0.000	0.000	0.000	0.290	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000
Canneries	0.206	0.044	0.061	0.000	0.126	0.000	0.000	0.086	0.002	0.217	0.228	0.000	0.000	0.000	0.000	0.000
Starch	0.014	0.352	0.000	0.000	0.148	0.000	0.000	0.173	0.000	0.000	0.024	0.000	0.289	0.000	0.000	0.000
Flour products	0.000	0.113	0.140	0.000	0.213	0.000	0.000	0.021	0.003	0.000	0.364	0.000	0.000	0.124	0.002	0.000
Sugar	0.000	0.036	0.000	0.000	0.036	0.000	0.000	0.532	0.058	0.044	0.079	0.000	0.000	0.206	0.000	0.000
Ice cream	0.000	0.000	0.234	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.766	0.000	0.000	0.000	0.000	0.000
Seasoning	0.065	0.569	0.017	0.000	0.019	0.000	0.000	0.064	0.000	0.000	0.222	0.000	0.000	0.000	0.000	0.000
Animal feed	0.034	0.311	0.095	0.000	0.242	0.000	0.000	0.043	0.000	0.104	0.088	0.000	0.000	0.081	0.000	0.000
Alcohol/Liquor	0.000	0.000	0.000	0.000	0.717	0.000	0.000	0.000	0.000	0.150	0.014	0.000	0.000	0.000	0.119	0.000
Ethanol	0.319	0.161	0.000	0.082	0.437	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wine	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Beer	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Soft drink	0.000	0.287	0.000	0.000	0.016	0.000	0.000	0.229	0.000	0.022	0.244	0.000	0.000	0.000	0.000	0.000
Textile	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.008	0.071	0.033	0.460	0.000	0.000	0.004	0.145	0.000
Tannery	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.052	0.000	0.000	0.000	0.000	0.000
Paper and pulp	0.000	0.000	0.000	0.000	0.143	0.000	0.000	0.022	0.039	0.023	0.717	0.000	0.000	0.056	0.000	0.000
Chemical products	0.000	0.410	0.080	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.408	0.000	0.000	0.001	0.086	0.000
Petrochemical products	0.000	0.000	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.409	0.000	0.000	0.000	0.000	0.000
Soap and Detergents	0.000	0.000	0.014	0.000	0.000	0.000	0.000	0.062	0.000	0.000	0.530	0.000	0.000	0.394	0.000	0.000
Petroleum Refining	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.464	0.000	0.000	0.000	0.000	0.000
Rubber	0.000	0.000	0.000	0.000	0.075	0.000	0.000	0.204	0.000	0.228	0.283	0.000	0.008	0.147	0.000	0.000

Emission Factors of Industrial Wastewater Treatment and Discharge (5D2)

Parameters and emission factors for use in estimation of greenhouse gas emission from industrial wastewater treatment and discharge follow the 2006 IPCC guidelines, as listed in Table 2-173.

Table 2-173: Emission factors of industrial wastewater treatment and discharge (5D2)

Parameters	Unit	Item	value	Reference
Maximum CH_4 producing capacity (B_0)	kg CH_4/kg COD	Industrial wastewater	0.25	2006 IPCC Guidelines
Methane conversion factor (MCF)	fraction	Untreated - Sea, river and lake discharge	1.0	2006 IPCC Guidelines
		- Aerobic treatment plant (Must be well managed)	0	
		- Aerobic treatment plant (Not well managed)	0.3	
		- Anaerobic digester for sludge	0.8	
		- Anaerobic reactor	0.8	
		- Anaerobic shallow lagoon	0.2	
		- Anaerobic deep lagoon	0.8	

Uncertainty

The uncertainty analysis of greenhouse gas emissions estimation of industrial wastewater treatment and discharge (5D2) is divided into two parts:

- uncertainty based on Activity Data, which includes the total industrial product for the industrial sector, amount of organic pollution in the terms of chemical oxygen demand (COD), wastewater generated from individual sectors (Wi), and COD of wastewater (COD). Default values from the 2006 IPCC Guidelines are applied, resulting in an uncertainty of ±55.90%.

- uncertainty of Emission Factors, which includes the maximum methane production potential (B_0), and the methane correction factor (MCF) for the treatment or discharge methods. The uncertainty for emission factors is ±31.62%.

When calculating the combined uncertainty for the industrial wastewater treatment and discharge (5D2), the resulting value is ±64.22%, as shown in Table 2-174.

Table 2-174: Uncertainty analysis of industrial wastewater treatment and discharge (5D2)

Parameters	Data source	value	Uncertainty Range		Reference
			High	Low	
Activity data					
Total industrial product for industrial sector (Pi)	Country	-	-25%	+25%	2006 IPCC GL
Wastewater generated from individual sector (Wi), COD of wastewater (COD)	Country	-	-50%	+50%	
Uncertainty based on activity data			±55.90%		
Emission factors					
Maximum CH_4 producing capacity (B_0)	Default	0.25	-30%	+30%	2006 IPCC GL
Methane correction factor (MCF)	Default	-	-10%	+10%	
Uncertainty based on emission factor			±31.62%		
Combined uncertainty: Industrial wastewater treatment and discharge (5D2)			±64.22%		

Time-series Consistency

To achieve time-series consistency in the activity data, the relevant agencies, i.e. DIW, OIE, and DEDE, use standardized methods for data collection across all years, ensuring that definitions, classifications, and methodologies remain consistent. The same emission factors are used throughout the time series.

Category-specific QA/QC Procedures

The QC procedures have been conducted in accordance with the 2006 IPCC Guidelines by checking of the parameters for activity data and emission factors and the archiving of reference materials.

Category-specific Planned Improvements

For improving the accuracy, reliability, and completeness of the GHG inventory in the industrial wastewater treatment and discharge (5A2), the following approaches are recommended:

- Upgrading data collection systems to ensure more consistent reporting from treatment facilities,
- Developing updated emission factors that reflect technological advancements or variations in wastewater composition,
- Collaborating with research institutions to derive more representative methane (CH_4) and nitrous oxide (N_2O) emission factors,
- Capacity building for personnel involved in wastewater GHG inventory to enhance their understanding of IPCC guidelines and best practices,
- Increasing collaboration with stakeholders to ensure consistent and high-quality data submissions.

Estimated Emissions from Industrial Wastewater Treatment and Discharge (5D2)

Greenhouse gas emissions from industrial wastewater treatment and discharge (5D2) are primarily methane (CH_4) emissions. Table 2-175 and Figure 2-75 present estimated greenhouse gas emissions from industrial wastewater treatment and discharge (5D2), comparing scenarios with and without methane recovery. Emissions have declined since 2009, largely due to improved methane recovery, reflecting advancements in renewable energy initiatives under the Alternative Energy Development Plan (AEDP).

Table 2-175: Emissions from industrial wastewater treatment and discharge (5D2) during 2000-2022

Year	GHG emission ($ktCO_2eq$)		
	CH_4 generated	CH_4 recovery	CH_4 emissions
2000	4,889.36	-	4,889.36
2001	5,167.41	-	5,167.41
2002	6,300.87	-	6,300.87
2003	7,451.56	-	7,451.56
2004	7,739.58	-	7,739.58
2005	7,653.50	-	7,653.50
2006	8,395.31	51.31	8,344.00
2007	8,651.52	74.49	8,577.03
2008	10,011.49	503.34	9,508.15
2009	10,831.59	1,685.43	9,146.16
2010	10,568.40	3,131.30	7,437.11
2011	11,816.97	5,824.87	5,992.10
2012	12,800.69	10,634.93	2,165.76
2013	16,299.48	12,346.49	3,952.99
2014	18,162.85	13,505.17	4,657.67
2015	20,316.50	14,475.40	5,841.11
2016	22,664.60	16,276.20	6,388.40
2017	25,303.33	18,221.22	7,082.10
2018	28,843.09	23,200.42	5,642.67
2019	30,329.57	24,084.37	6,245.20
2020	26,284.52	19,221.97	7,062.55
2021	26,288.68	19,333.07	6,955.61
2022	28,572.75	19,478.41	9,094.34

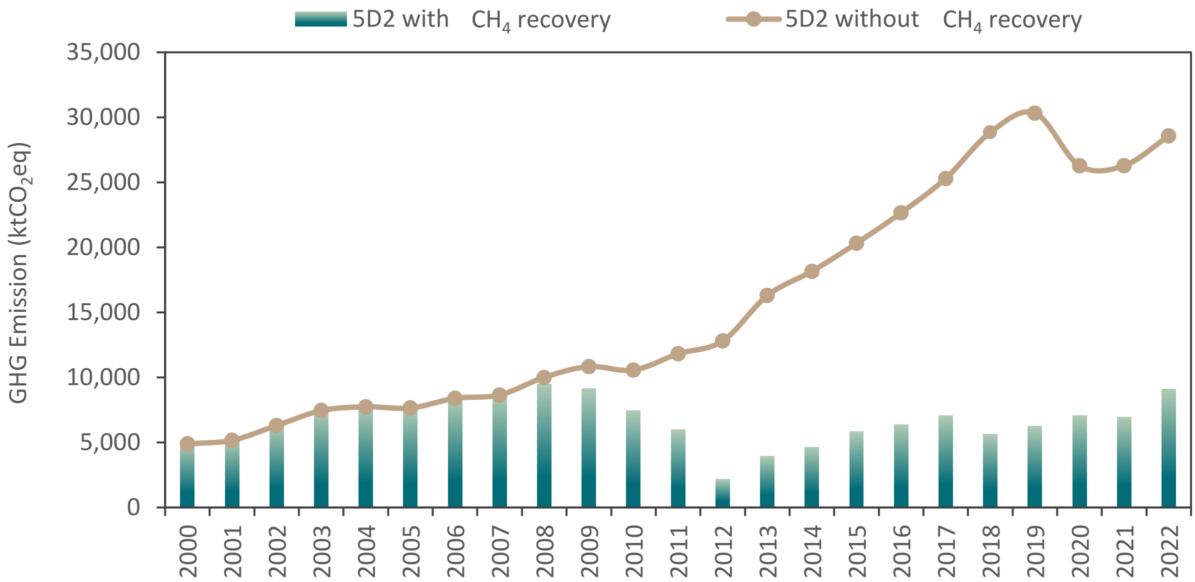


Figure 2-75: Emissions from industrial wastewater treatment and discharge (5D2) for 2020-2022

Estimated Emissions from Wastewater Treatment and Discharge (5D)

The estimation of greenhouse gas emissions from wastewater treatment and discharge (5D) is categorized into two main areas: domestic wastewater treatment and discharge (5D1) and industrial wastewater treatment and discharge (5D2). Figure 2-76 presents greenhouse gas emissions by source, distinguishing between domestic and industrial wastewater contributions. Notably, the data for industrial wastewater includes the amount of methane (CH_4) recovered for beneficial use. Emissions decreased in 2018–2019, largely due to enhanced methane recovery, highlighting progress in renewable energy initiatives under the Alternative Energy Development Plan (AEDP2018) for 2018–2037.

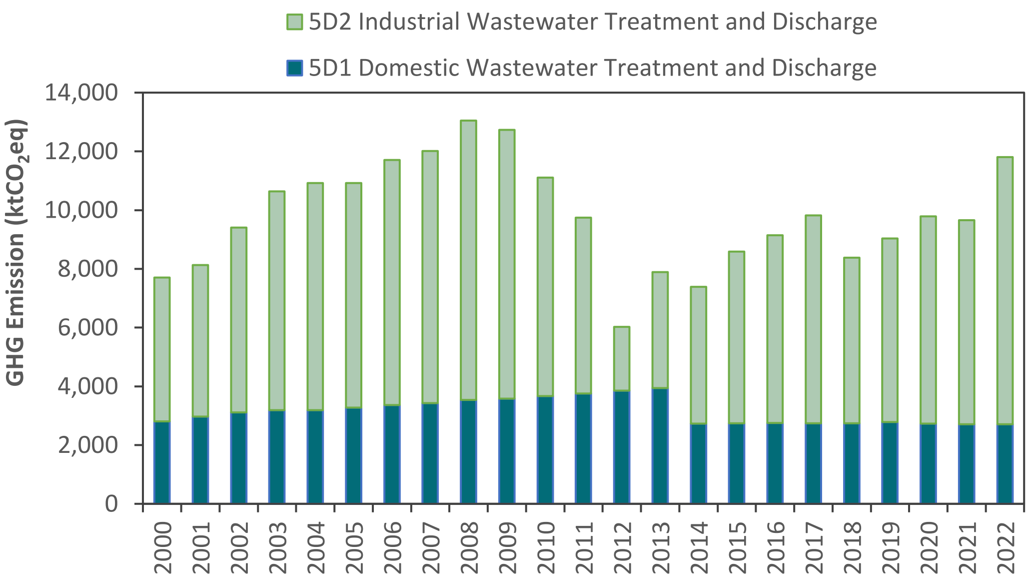


Figure 2-76: Greenhouse gas emissions from wastewater treatment and discharge for 2000-2022, categorized by type of wastewater (5D)

Greenhouse Gas Emissions from Waste Sector during 2020-2022

The assessment of greenhouse gas emissions from the waste sector revealed that three types of greenhouse gases are emitted: methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2). Methane is emitted from all activity groups (5A, 5B, 5C, and 5D), nitrous oxide from groups 5B, 5C, and 5D, and carbon dioxide solely from group 5C. When calculating emissions in kilotons of carbon dioxide equivalent (ktCO_2eq), methane consistently accounted for the highest emissions each year, followed by nitrous oxide and carbon dioxide, respectively.

Table 2-176 and Figure 2-77 present the emissions of greenhouse gases from the waste sector in Thailand over the years 2000 to 2022, categorized by the specific types of gases emitted: methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2). The data provides an annual breakdown, illustrating the trends and amounts of each gas type released in kilotons of carbon dioxide equivalent (ktCO_2eq) throughout the specified period. Figure 2-78 presents the relative trend of GHG emission by gas type compared to the emission at the base year (2000). Additionally, when analyzing emissions by subcategory, it was found that wastewater treatment and discharge (5D) contributed the highest emissions in the waste sector, followed by solid waste disposal (5A), incineration and open burning of waste (5C), and biological treatment of solid waste (5B), as shown in Figure 2-79.

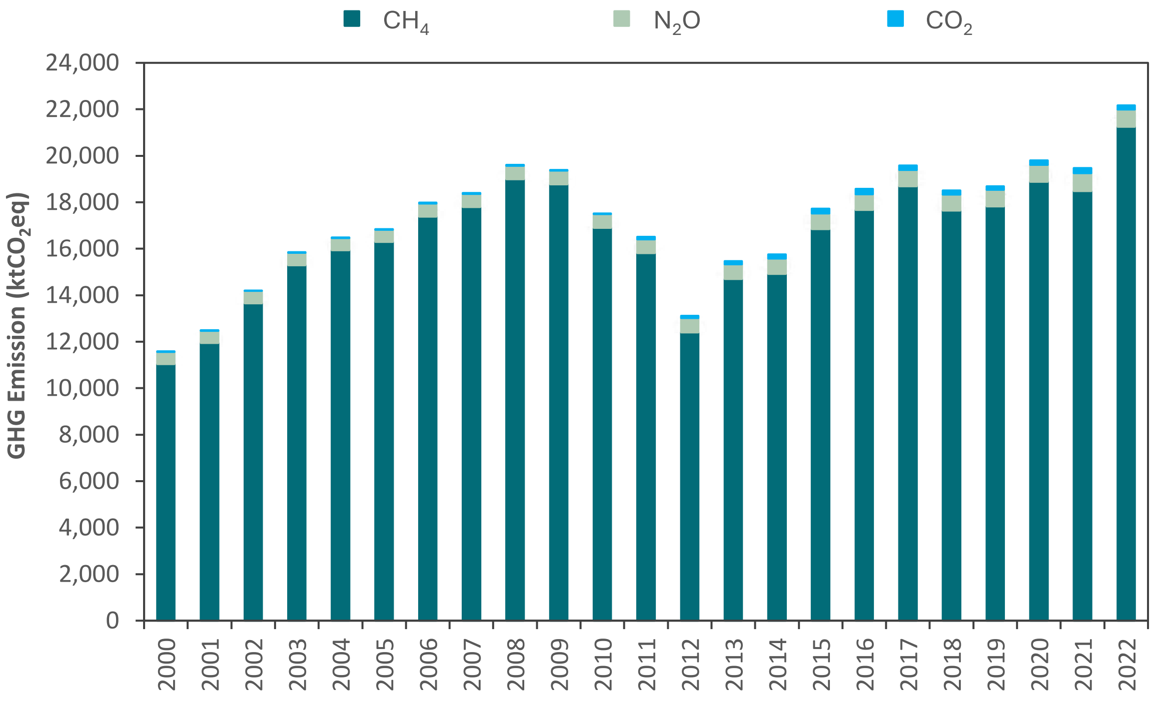


Figure 2-77: GHG emissions in the Waste sector, categorized by gas for 2000–2022

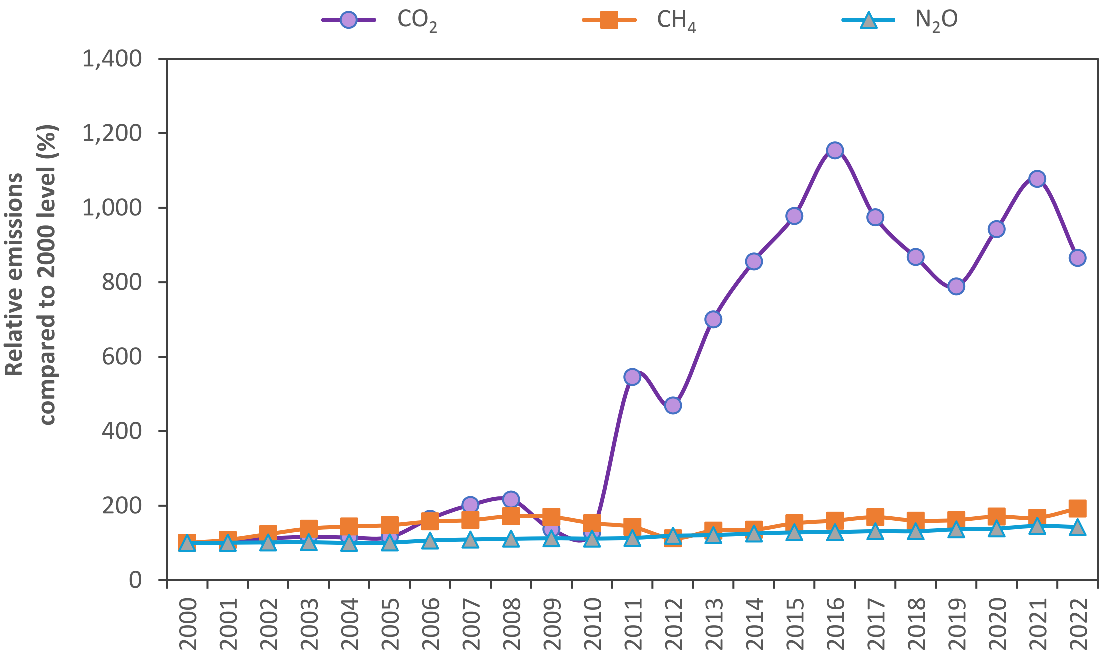


Figure 2-78: Relative trends of GHG emissions in the Waste sector (base year is 2000)

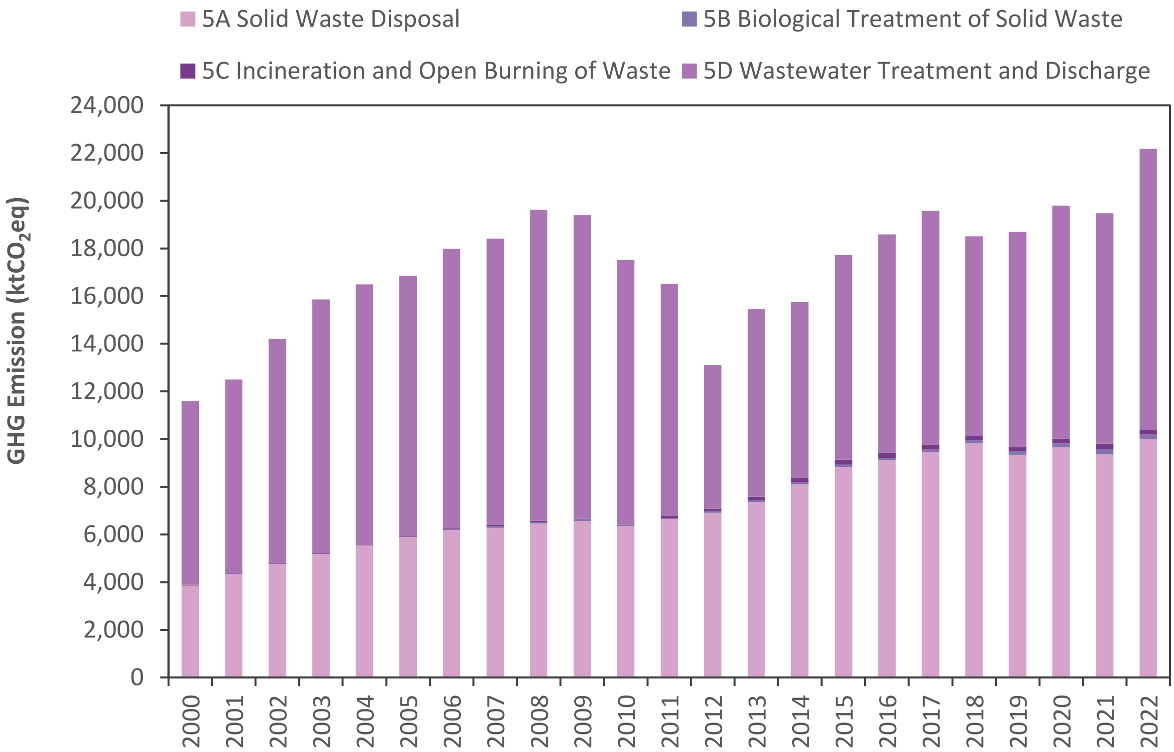


Figure 2-79: GHG emissions in the Waste sector by subsector for 2000–2022

Table 2-176: GHG emissions in the Waste sector by types of gas for 2000-2022

Year	GHG Emission ($ktCO_2eq$)			
	CO_2	CH_4	N_2O	Total
2000	20.27	11,038.64	525.32	11,584.23
2001	20.97	11,945.30	528.99	12,495.26
2002	22.68	13,654.36	533.21	14,210.25
2003	23.63	15,294.62	535.61	15,853.86
2004	23.25	15,936.85	526.24	16,486.35
2005	23.40	16,294.09	530.02	16,847.51
2006	33.46	17,387.90	560.45	17,981.81
2007	40.91	17,788.54	574.59	18,404.05
2008	43.90	18,986.50	583.90	19,614.30
2009	27.80	18,774.66	591.10	19,393.56
2010	25.89	16,903.60	587.06	17,516.55
2011	110.53	15,814.41	596.18	16,521.13
2012	95.03	12,396.46	625.68	13,117.17
2013	141.97	14,694.71	636.61	15,473.29
2014	173.57	14,923.15	658.02	15,754.73
2015	198.27	16,847.17	674.31	17,719.75
2016	233.99	17,668.02	678.40	18,580.41
2017	197.53	18,693.79	691.66	19,582.99
2018	175.84	17,641.20	690.75	18,507.80
2019	159.86	17,819.09	717.53	18,696.48
2020	191.04	18,880.07	728.17	19,799.28
2021	218.39	18,486.11	766.45	19,470.95
2022	175.49	21,247.11	750.37	22,172.96

Greenhouse Gas Emissions in the Waste Sector in 2020

In 2020, greenhouse gas emissions from waste sector activities totaled 19,799.28 $ktCO_2eq$. Table 2-177 shows the greenhouse gas emissions from waste sector in the CRT format, categorized by subsector and gas type. By subsector, wastewater treatment and discharge (5D) and solid waste disposal (5A) accounted for the highest emissions, at 9,791.16 $ktCO_2eq$ (49.20%) and 9,646.58 $ktCO_2eq$ (48.72%), respectively. This was followed by waste incineration and open burning (5C) at 196.16 $ktCO_2eq$ (0.99%) and biological treatment of solid waste (5B), which had the lowest emissions at 165.39 $ktCO_2eq$ (0.84%), as illustrated in Figure 2-80.

When considering gas type for the waste sector in 2020, methane (CH_4) emission was the highest, totaling 18,880.07 $ktCO_2eq$ (95.36%), followed by nitrous oxide (N_2O) at 728.17 $ktCO_2eq$ (3.68%) and carbon dioxide (CO_2) at 191.04 $ktCO_2eq$ (0.96%), as shown in Figure 2-81.

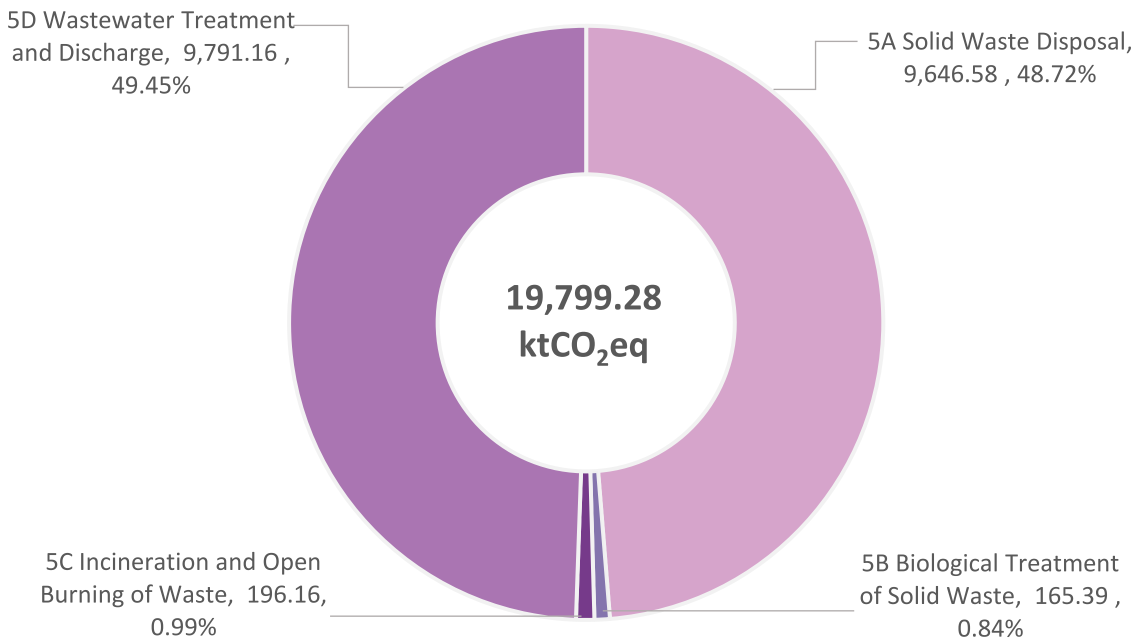


Figure 2-80: GHG emissions in the Waste sector in 2020

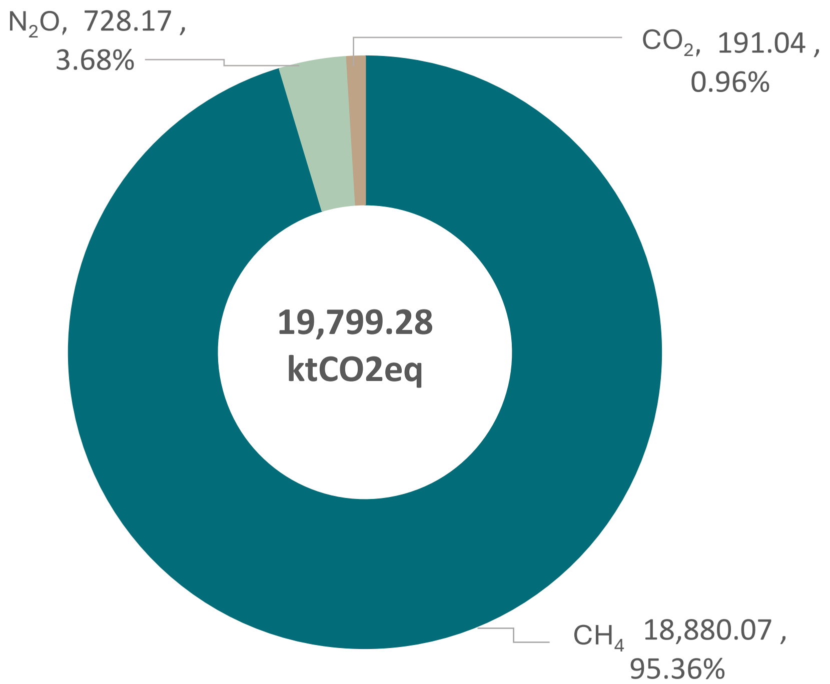


Figure 2-81: GHG emissions in the Waste sector by types of gas in 2020

Table 2-177: Summary of GHG emissions in the Waste sector in 2020

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_x	Total GHG emissions
	(kt)							($ktCO_2eq$)
5. Total waste	191.04	18,880.07	728.17	NO/NA	NO/NA	NA	NA	19,799.28
5.A. Solid waste disposal		9,646.58		NA	NA	NA		9,646.58
5.A.1. Managed waste disposal sites		4,541.82		NA	NA	NA		4,541.82
5.A.2. Unmanaged waste disposal sites		5,104.76		NA	NA	NA		5,104.76
5.A.3. Uncategorized waste disposal sites		NO		NA	NA	NA		NO/NA
5.B. Biological treatment of solid waste		80.13	85.26	NO	NO	NA		165.39
5.B.1. Composting		66.72	37.89	NO	NO	NA		104.61
5.B.2. Anaerobic digestion at biogas facilities		0.90	0.00	NO	NO	NA		0.90
5.B.3. Mechanical biological treatment		12.51	47.37	NO	NO	NA		59.88
5.C. Incineration and open burning of waste	191.04	0.69	4.42	NA	NA	NA		196.16
5.C.1. Waste incineration	191.04	0.69	4.42	NA	NA	NA	NA	196.16
5.C.2. Open burning of waste	NO	NO	NO	NA	NA	NA	NA	NA
5.D. Wastewater treatment and discharge		9,152.67	638.48	NO	NO	NA		9,791.15
5.D.1. Domestic wastewater		2,090.12	638.48	NO	NO	NA		2,728.60
5.D.2. Industrial wastewater		7,062.55	NO	NO	NO	NA		7,062.55
5.D.3. Other		NO	NO	NO	NO	NA		NO/NA

Note: NA = Not Applicable , NO = Not Occurring

Greenhouse Gas Emissions in the Waste Sector in 2021

In 2021, total greenhouse gas emissions from waste sector amounted to 19,470.95 ktCO_2eq. Table 2-178 shows the greenhouse gas emissions from waste sector in the CRT format, categorized by subsector and gas type. Like the previous year, wastewater treatment and discharge (5D) and solid waste disposal (5A) accounted for the highest emissions at 9,661.50 ktCO2eq (49.62%) and 9,355.82 ktCO_2eq (48.05%), respectively. Biological treatment of solid waste (5B) emitted 230.03 ktCO_2eq (1.18%), while waste incineration and open burning (5C) produced the lowest emissions at 223.60 ktCO_2eq (1.15%), as shown in Figure 2-82.

Considering the type of greenhouse gas in the waste sector for 2021, methane (CH_4) emission was the highest at 18,486.11 ktCO_2eq (94.94%), followed by nitrous oxide (N_2O) at 766.45 ktCO_2eq (3.94%) and carbon dioxide (CO_2) at 218.39 ktCO_2eq (1.12%), as shown in Figure 2-83.

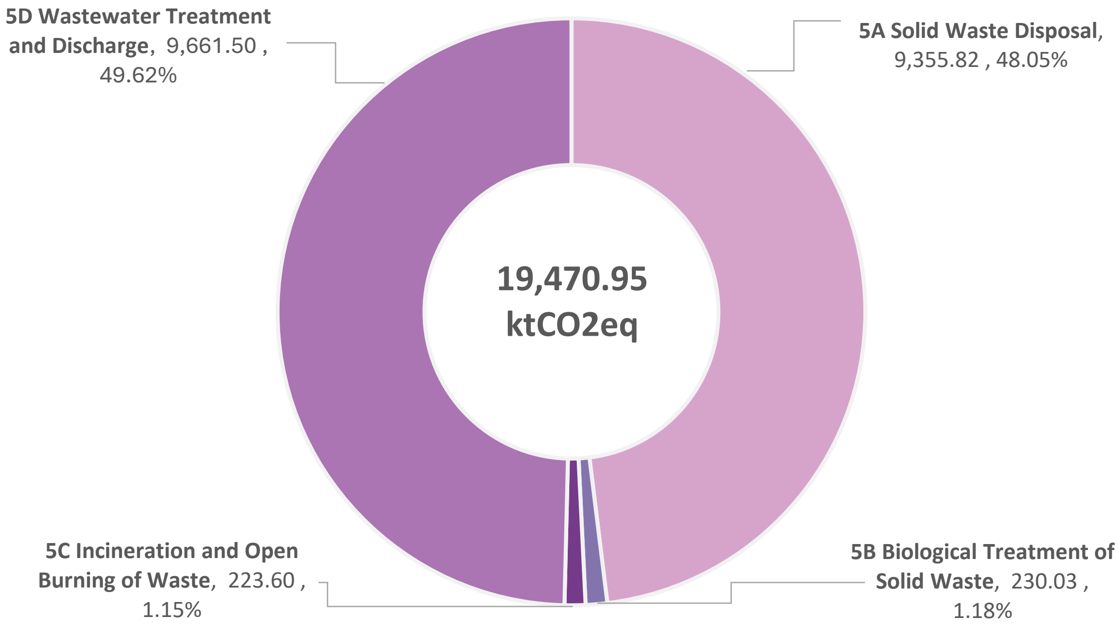


Figure 2-82: GHG emissions in the Waste sector in 2021

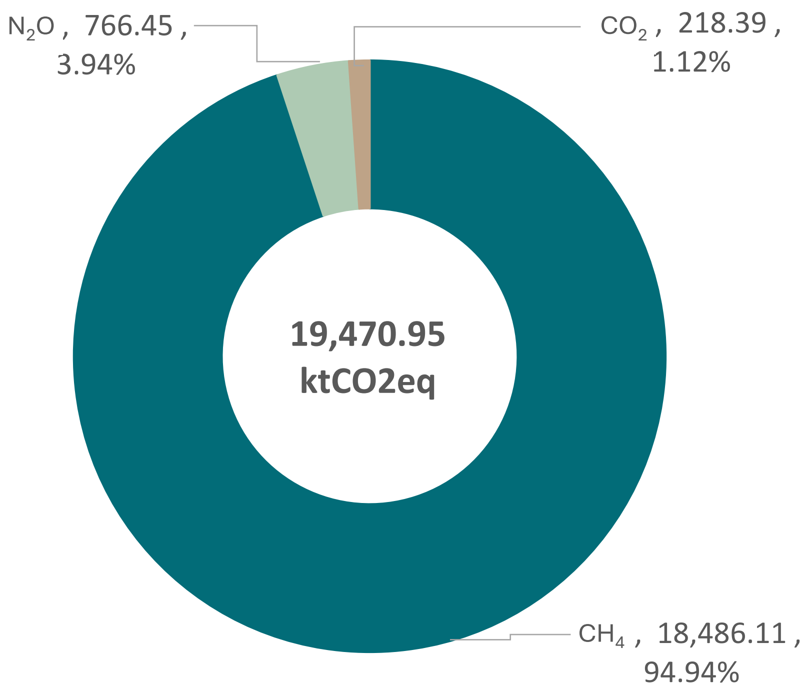


Figure 2-83: GHG emissions in the Waste sector by types of gas in 2021

Table 2-178: Summary of GHG emissions in the Waste sector in 2021

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_x	Total GHG emissions
	(kt)							($ktCO_2eq$)
5. Total waste	218.39	18,486.11	766.45	NO/NA	NO/NA	NA	NA	19,470.95
5.A. Solid waste disposal		9,355.82		NA	NA	NA		9,355.82
5.A.1. Managed waste disposal sites		5,560.37		NA	NA	NA		5,560.82
5.A.2. Unmanaged waste disposal sites		3,795.45		NA	NA	NA		3,795.45
5.A.3. Uncategorized waste disposal sites		NA		NA	NA	NA		NO/NA
5.B. Biological treatment of solid waste		106.49	123.54	NO	NO	NA		230.03
5.B.1. Composting		86.11	48.90	NO	NO	NA		135.01
5.B.2. Anaerobic digestion at biogas facilities		0.66	0.00	NO	NO	NA		0.66
5.B.3. Mechanical biological treatment		19.72	74.64	NO	NO	NA		94.36
5.C. Incineration and open burning of waste	218.39	0.65	4.57	NA	NA	NA		223.60
5.C.1. Waste incineration	218.39	0.65	4.57	NA	NA	NA	NA	223.60
5.C.2. Open burning of waste	NA	NA	NO	NA	NA	NA	NA	NA
5.D. Wastewater treatment and discharge		9,023.16	638.34	NO	NO	NA		9,661.50
5.D.1. Domestic wastewater		2,067.55	638.34	NO	NO	NA		2,705.89
5.D.2. Industrial wastewater		6,955.61	NO	NO	NO	NA		6,955.61
5.D.3. Other		NO	NO	NO	NO	NA		NO/NA

Note: NA = Not Applicable , NO = Not Occurring

Greenhouse Gas Emissions in the Waste Sector in 2022

In 2022, total greenhouse gas emissions from waste sector amounted to 22,172.96 ktCO_2eq. Table 2-179 shows the greenhouse gas emissions from waste sector in the CRT format, categorized by subsector and gas type. Like the previous year, wastewater treatment and discharge (5D) and solid waste disposal (5A) accounted for the highest emissions at 11,802.17 ktCO_2eq (53.23%) and 9,988.81 ktCO_2eq (45.05%), respectively. Biological treatment of solid waste (5B) emitted 202.29 ktCO_2eq (0.91%), while waste incineration and open burning (5C) had the lowest emissions at 179.69 ktCO_2eq (0.81%), as shown in Figure 2-84.

Considering the type of greenhouse gas in the waste sector for 2022, methane (CH_4) emission was the highest at 21,247.11 ktCO_2eq (95.82%), followed by nitrous oxide (N_2O) at 750.37 ktCO_2eq (3.38%) and carbon dioxide (CO_2) at 175.49 ktCO_2eq (0.79%), as shown in Figure 2-85.

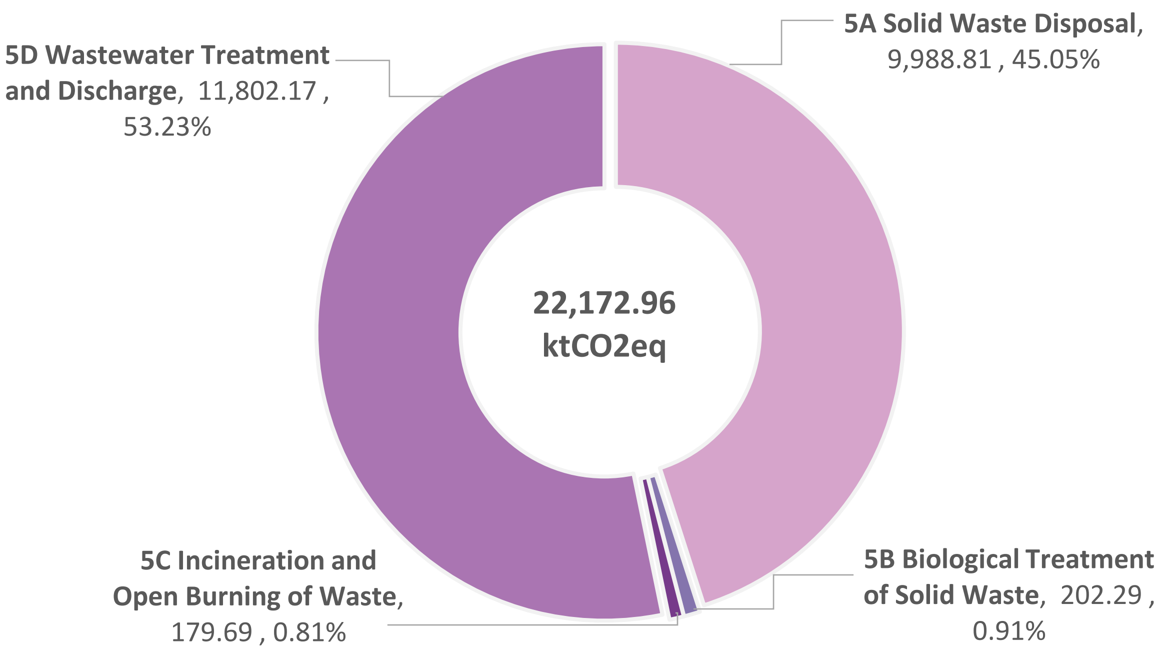


Figure 2-84: GHG emissions in Waste sector in 2022

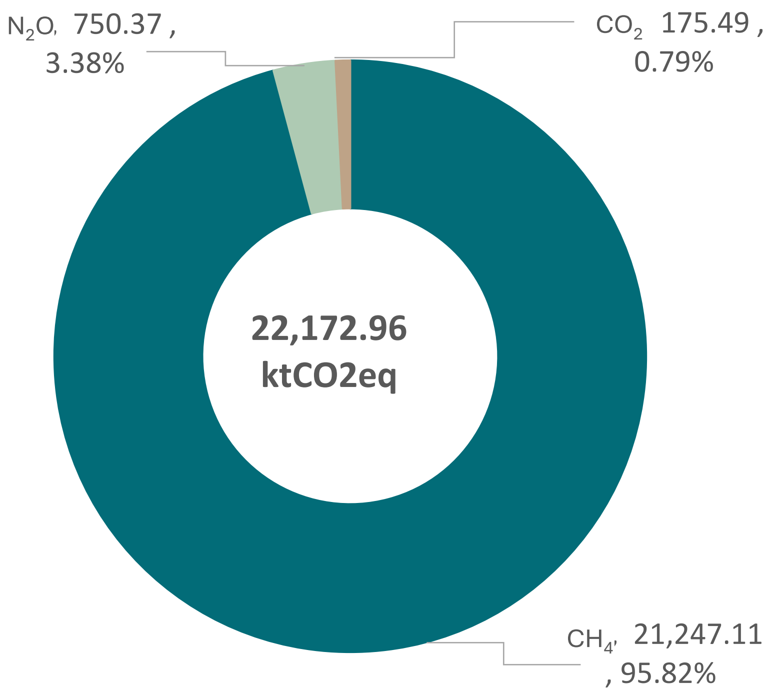


Figure 2-85: GHG emissions in the Waste sector by types of gas in 2022

Table 2-179: Summary of GHG emissions in the Waste sector in 2022

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_x	Total GHG emissions
	(kt)							($ktCO_2eq$)
5. Total waste	175.49	21,247.11	750.37	NO/NA	NO/NA	NA	NA	22,177.96
5.A. Solid waste disposal		9,988.81		NA	NA	NA		9,988.81
5.A.1. Managed waste disposal sites		6,386.24		NA	NA	NA		6,386.24
5.A.2. Unmanaged waste disposal sites		3,602.58		NA	NA	NA		3,602.58
5.A.3. Uncategorized waste disposal sites		NA		NA	NA	NA		NO/NA
5.B. Biological treatment of solid waste		93.28	109.01	NO	NO	NA		202.29
5.B.1. Composting		75.86	43.08	NO	NO	NA		118.94
5.B.2. Anaerobic digestion at biogas facilities		0.00	0.00	NO	NO	NA		0.00
5.B.3. Mechanical biological treatment		17.42	65.93	NO	NO	NA		83.35
5.C. Incineration and open burning of waste	175.49	0.40	3.80	NA	NA	NA		179.69
5.C.1. Waste incineration	175.49	0.40	3.80	NA	NA	NA	NA	179.69
5.C.2. Open burning of waste	NA	NA	NO	NA	NA	NA	NA	NA
5.D. Wastewater treatment and discharge		11,164.61	637.56	NO	NO	NA		11,802.17
5.D.1. Domestic wastewater		2,070.27	637.56	NO	NO	NA		2,707.83
5.D.2. Industrial wastewater		9,094.34	NO	NO	NO	NA		9,094.34
5.D.3. Other		NO	NO	NO	NO	NA		NO/NA

Note: NA = Not Applicable , NO = Not Occurring

Recalculation in Solid Waste Disposal (5A)

Comparison of time-series GHG emissions in solid waste disposal (5A) sector between Tier 1 and Tier 2 is presented in Figure 2-86, and time-series percentage difference of emissions is presented in Figure 2-87.

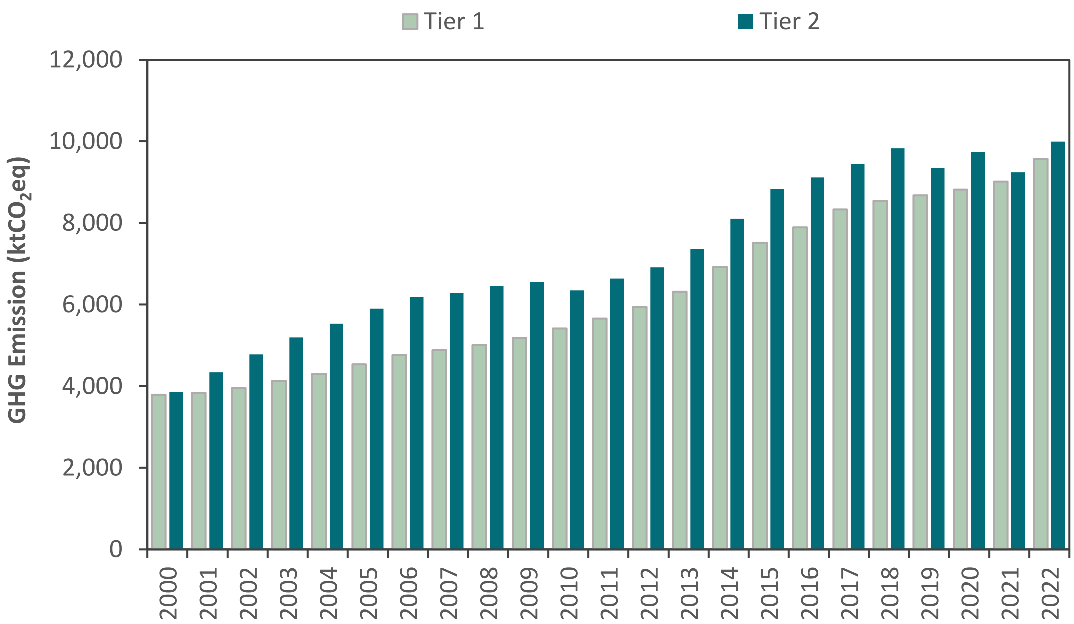


Figure 2-86: Comparison of GHG emissions in solid waste disposal (5A) sector between Tier 1 and Tier 2

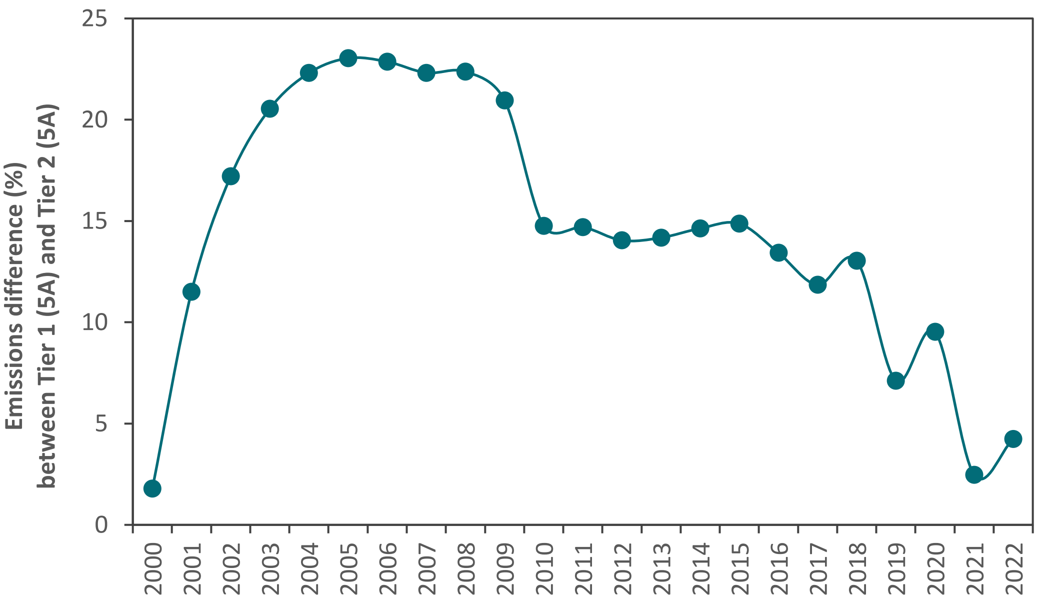


Figure 2-87: Percentage difference of emissions in solid waste disposal (5A) sector between Tier 1 and Tier 2

Recalculation and Improvement in the Waste Sector

Comparison of time-series GHG emissions in the Waste sector between Tier 1 and Tier 2 is presented in Figure 2-88, and time-series percentage difference of emissions is presented in Figure 2-89.

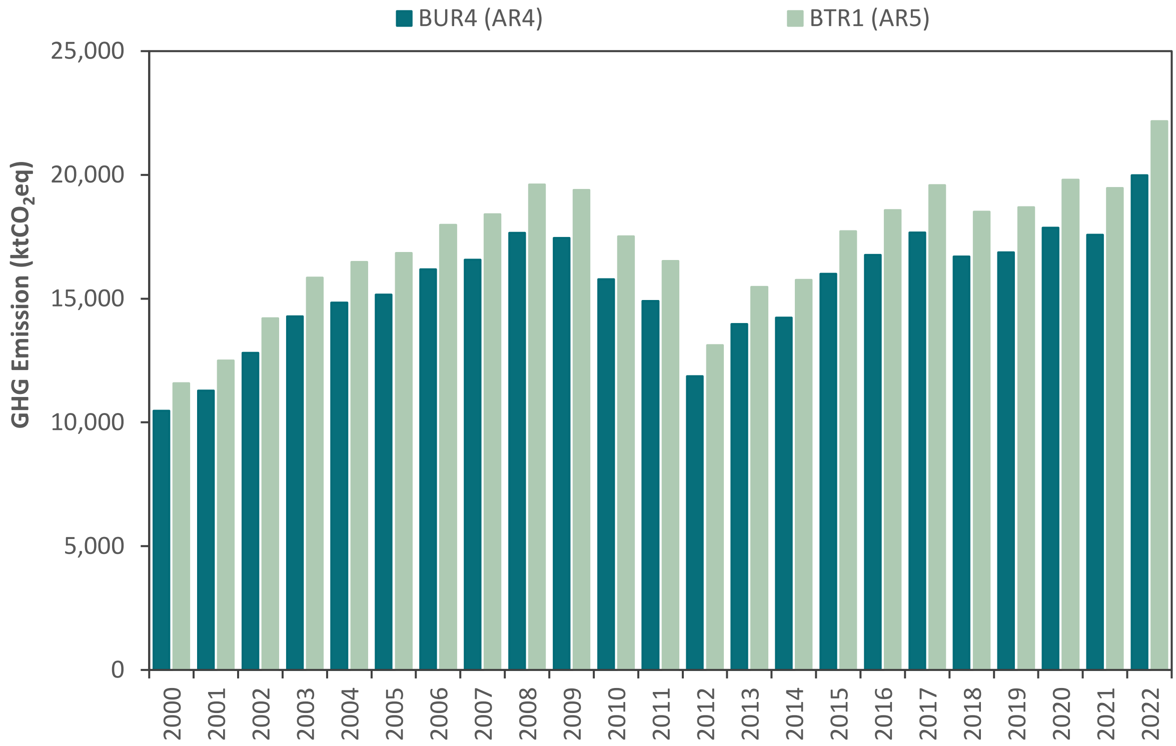


Figure 2-88: Comparison of GHG emissions in the Waste sector between BTR1 and BUR4

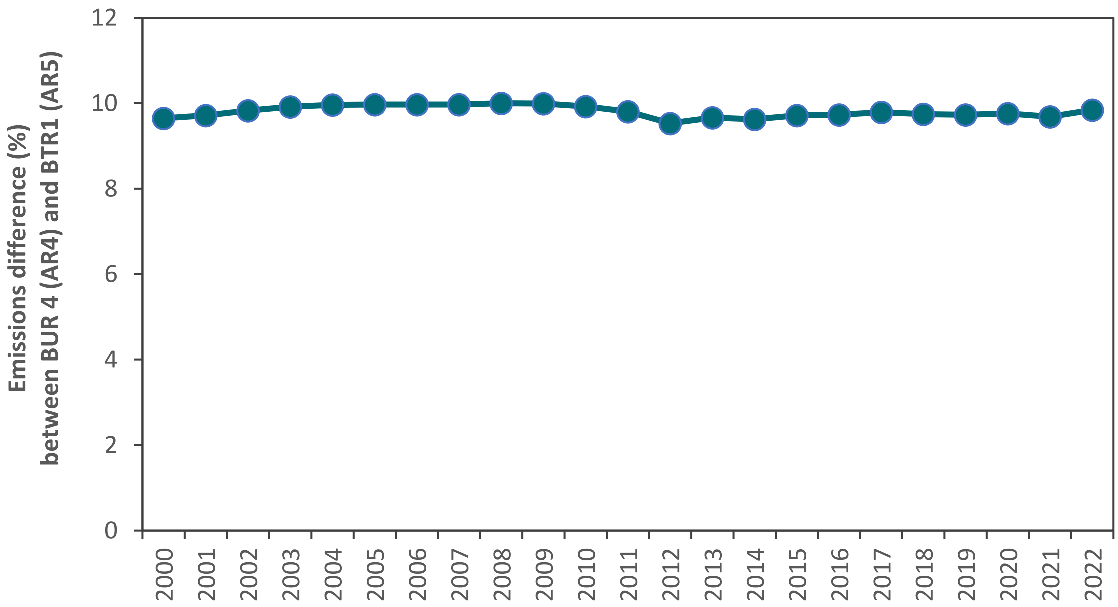


Figure 2-89: Percentage difference of emissions in the Waste sector in BTR1 compared to BUR4

2.5 LAND USE, LAND USE CHANGE AND FORESTRY

Methodology

The land use, land use change, and forestry (LULUCF) sector involves greenhouse gas (GHG) emissions from land management activities that affect the amount of carbon stored in soils and vegetation. Vegetation can sequester carbon from the atmosphere, enabling this sector to act as a net sink for emissions. All methodologies and tools used to report GHG inventories for LULUCF were consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), Good Practice Guidance for Land Use, Land–use Change, and Forestry (IPCC, 2003), and Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000). The 2006 IPCC Guidelines define six land–use categories: forest land, cropland, grassland, wetlands, settlements, and other lands. Consistent with the inventories in the Third Biennial Update Report (BUR3) and the Fourth Biennial Update Report (BUR4), GHG emissions and removals from the LULUCF sector for the period 2000–2021 were estimated for three of these land categories (forest land, cropland, and other lands), excluding grassland, wetlands, and settlements. The following land subcategories were reported: forest land remaining forest land, cropland remaining cropland, land converted to cropland, land converted to other land, and biomass burning. In addition to the three land categories as reported, preparation of activity data, emission factors, and methodologies for estimating GHG emissions and removals in the wetlands and settlements categories is currently underway. The GHG inventories of Thailand did not include grassland since the area is less than 0.4% of the total forest land, the majority of which is small fragments and located among forest land.

The Tier 2 methodology was used primarily wherever activity data and country–specific emission factors were available. For carbon stock change estimation, change in below-ground biomass carbon stocks was estimated using country-specific data ratios of below-ground to above-ground biomass wherever applicable. Dead organic matter (DOM) or dead wood and litter was not quantified for land areas that remain in a land-use category. Gain-Loss Method was applied to all carbon gains or losses. The carbon changes in harvested wood products (HWP) were not reported. Approach 1 in the 2006 IPCC Guidelines was adopted for representing land–use areas of which total land–use areas in each stratification were reported without data on conversions between land uses. In accordance with Approach 3, the process of improving the representation of land-use areas by remote sensing techniques to classify the categories of natural forests and forest plantations and to monitor their changes every two years is currently underway.

Summary information on method and emission factor selection is provided in Table 2-180.

Table 2-180: Summary of methodologies and emission factors (EFs) in the LULUCF sector

GHG source and sink categories	CO_2		CH_4		N_2O		NOx		CO	
	Method applied	EF	Method applied	EF	Method applied	EF	Method applied	EF	Method applied	EF
4. Land Use, Land-Use Change and Forestry	**T1, T2**	**CS, D**	**T1, T2**	**CS, D**	**T1, T2**	**CS, D**	**T1, T2**	**CS, D**	**T1, T2**	**CS, D**
4A Forest Land Remaining Forest Land	T1, T2	CS, D								
Annual growth of forest plantations	T2	CS								
Logging/harvesting in forest plantations	T2	CS								
Forest regrowth through forest restoration	T1, T2	CS, D								
Forest regrowth through natural regeneration	T1, T2	CS, D								
Carbon losses due to biomass burning	T1, T2	CS, D								
4B Cropland Remaining Cropland	T1, T2	CS, D								
Annual growth of woody crops	T1, T2	CS								
Wood harvesting in woody crops	T1, T2	CS								
4C Land Converted to Cropland	T1, T2	CS, D								
Annual change in carbon stocks in biomass	T1, T2	CS, D								
Annual change in carbon stocks in dead organic matter	T2	CS, D								
4D Land Converted to Other Land	T1, T2	CS, D								
Annual change in carbon stocks in biomass										
Annual change in carbon stocks in dead organic matter										
4E Biomass Burning			T1, T2	CS, D	T1, T2	CS, D	T1, T2	CS, D	T1, T2	CS, D
4E1 Forest Land Remaining Forest Land			T1, T2	CS, D	T1, T2	CS, D	T1, T2	CS, D	T1, T2	CS, D
4E2 Land Converted to Cropland			T1, T2	CS, D	T1, T2	CS, D	T1, T2	CS, D	T1, T2	CS, D
4E3 Land Converted to Other Land			T1, T2	CS, D	T1, T2	CS, D	T1, T2	CS, D	T1, T2	CS, D

Note: T1: Tier 1, T2: Tier 2, EF: Emission factor, CS: Country specific, D: IPCC default

Values and Sources of Activity Data

The Department of Climate Change and Environment (DCCE) is responsible for creating the national greenhouse gas inventory. However, activity data for LULUCF sector involves various land responsible organizations including the Department of National Parks, Wildlife and Plant Conservation (DNP), the Royal Forest Department (RFD), the Department of Marine and Coastal Resources (DMCR), the Office of Agricultural Economics (OAE), the Forest Industry Organization (FIO), and the Rubber Authority of Thailand (RAOT). The DCCE in collaboration with the DNP, the LULUCF focal point agency, gathered activity data from agencies directly responsible for relevant data collection. To ensure a robust and transparent process for tracking GHG emissions and removals in the LULUCF sector, contributing to accurate national reporting, the measurement, reporting and verification (MRV) system was established. The steps for the activity data gathering to develop the national GHG inventory in LULUCF sector are as follows:

Activity data collection: Activity data on forestry and other land uses were gathered from agencies directly responsible for relevant data collection as described earlier. These agencies reported data using designated activity reporting forms accordingly for GHG emission calculations, as illustrated in Figure 2-90. The collected data was then analyzed, verified, and reported to the DNP and DCCE. The activity data sources in each subcategory are described in Table 2-181.

Verifying activity data and emission factors: Activity data and emission factors according to GHG source categories were reviewed. The activity data from multiple agencies (government, private sectors) were consolidated through resolution of the Working Group on Development of National GHG inventory in the LULUCF sector (WG-LULUCF), which consists of representatives from relevant agencies. If activity data and emission factors did not align with the assessment methodology or data completeness issues arose, WG-LULUCF reviewed the information and provided recommendations for preparing the data for inventory assessment.

Calculation using the IPCC worksheets: Activity data from individual agency forms were transferred to activity-specific forms, conducted pre-calculation, and calculated using the IPCC 2006 Worksheets for the LULUCF sector, employing Tier 1 and Tier 2 methods depending on data availability. Recalculation of emissions and removals in previous reports submitted to UNFCC was conducted where activity data and emission factors were revised.

Calculation and validation in TGEIS: These data were then prepared to enter into the Thailand Greenhouse Gas Emission Inventory System (TGEIS) using the Data Entry Template (DET), as shown in Figure 2-91. The input data was then calculated for GHG emission and removals, and validated by comparing it with the calculations by IPCC 2006 Worksheets. To ensure consistency and accuracy of TGEIS's calculation method, the current TGEIS-generated GHG emissions and removals were compared with that of previous reports submitted to the UNFCCC. The data of GHG emissions and removals was then transformed into the UNFCCC formatted reports including, national GHG inventory report, Common Reporting Table (CRT) and Biennial Transparency Report (BTR).

These steps ensure a robust and transparent process for tracking GHG emissions and removals in the LULUCF sector, contributing to accurate national reporting.

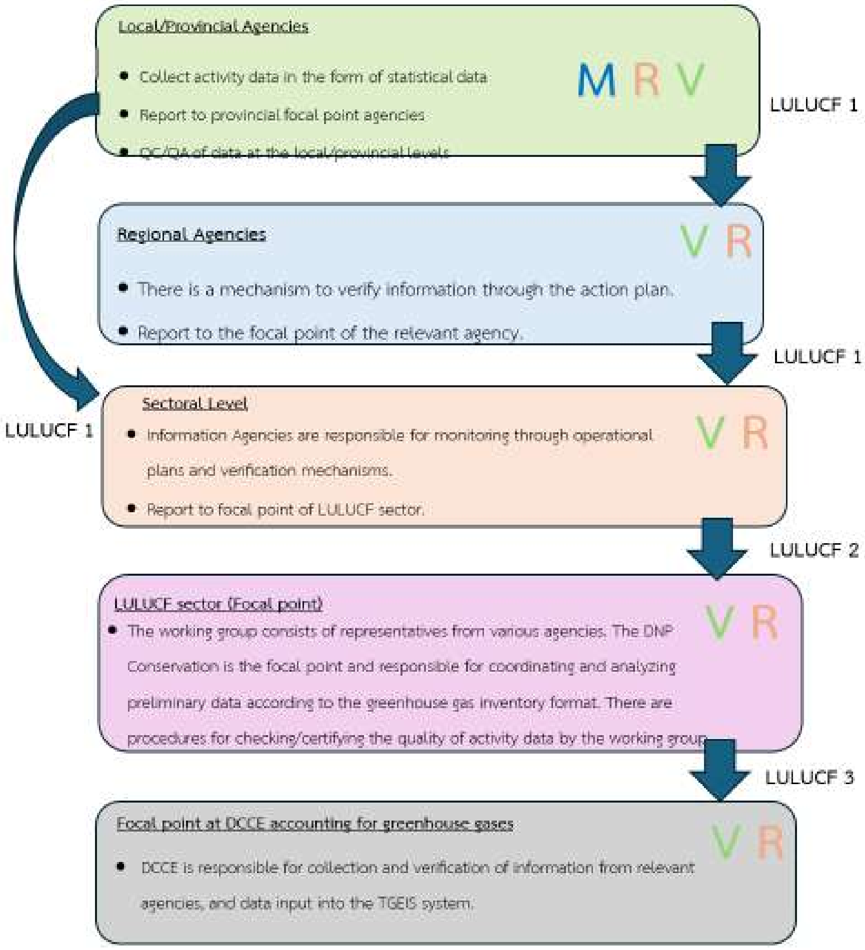


Figure 2-90: Structure of the measurement, reporting and verification (MRV) system for values and sources of activity data in the LULUCF sector

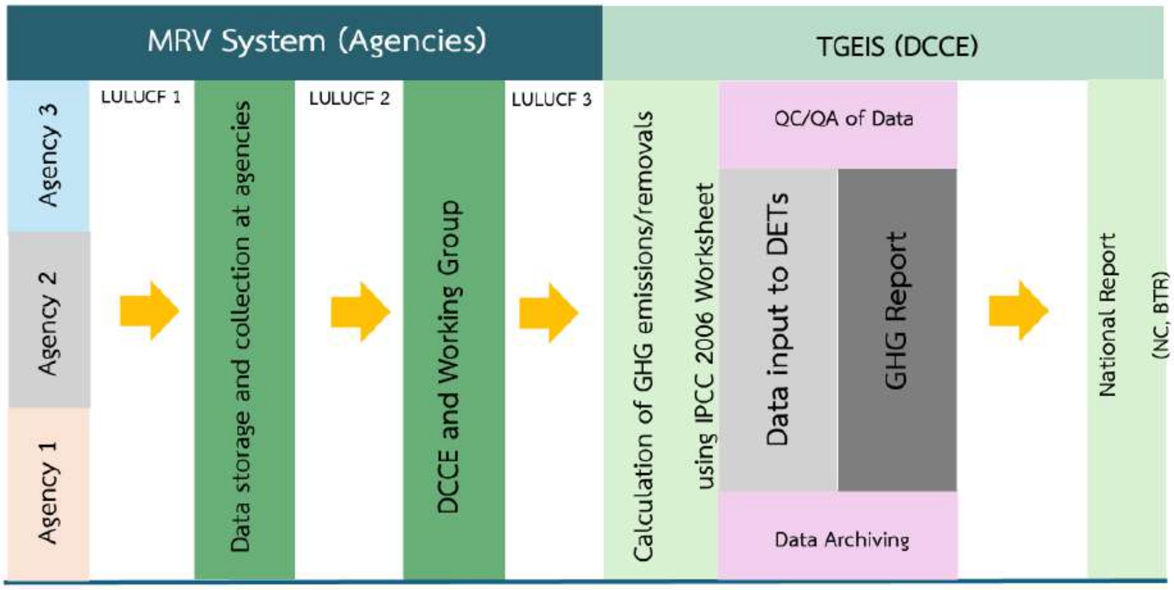


Figure 2-91: The measurement, reporting and verification (MRV) system in cooperation with the Thailand Greenhouse Gas Emission Inventory System (TGEIS) for the LULUCF sector

Table 2-181: Sources of activity data in the LULUCF sector

Category	Type of data	Data source
4. Land Use, Land-Use Change and Forestry		
4A Forest Land Remaining Forest Land		
Annual growth of forest plantations	Area of forest plantations by tree species/groups from 2000-2022 (ha)	Teak: Royal Forest Department, Forest Industry Organization Eucalyptus: Royal Forest Department, Forest Industry Organization, Private sector Pine: Forest Industry Organization Fast-growing species: Royal Forest Department, Forest Industry Organization, Private sector Slow-growing species: Royal Forest Department, Forest Industry Organization, Private sector Mangrove species: Department of Marine and Coastal Resources
Logging/harvesting in forest plantations	Area of harvested forest plantations (ha)	Royal Forest Department Forest Industry Organization
	Logging volume of harvested woods (m^3)	Royal Forest Department Forest Industry Organization
Forest regrowth through forest restoration	Total area of forest restoration (ha)	Royal Forest Department Department of National Parks, Wildlife and Plant Conservation Department of Marine and Coastal Resources
Forest regrowth through natural regeneration	Total area of degraded forests with natural regeneration (ha)	Royal Forest Department Department of National Parks, Wildlife and Plant Conservation
Carbon losses due to biomass burning	Total area of natural forest burned (ha)	Royal Forest Department Department of National Parks, Wildlife and Plant Conservation
4B Cropland Remaining Cropland		
Annual growth of woody crops	Area of rubber plantations from 2000-2022 (ha)	Royal Forest Department, Forest Industry Organization Rubber Authority of Thailand Office of Agricultural Economics
Wood harvesting in woody crops	Area of harvested forest plantations (ha) Logging volume of harvested woods (m^3)	Royal Forest Department, Forest Industry Organization Rubber Authority of Thailand Office of Agricultural Economics
4C Land Converted to Cropland		
Annual change in carbon stocks in biomass	Total area of natural forests converted to cropland (ha)	Royal Forest Department Department of National Parks, Wildlife and Plant Conservation Department of Marine and Coastal Resources
Annual change in carbon stocks in dead organic matter	Total area of natural forests converted to cropland (ha)	Royal Forest Department Department of National Parks, Wildlife and Plant Conservation Department of Marine and Coastal Resources

Table 2-181: Sources of activity data in the LULUCF sector (Cont'd)

Category	Type of data	Data source
4D Land Converted to Other Land		
Annual change in carbon stocks in biomass	Total area of natural forests converted to other land (ha)	Royal Forest Department Department of National Parks, Wildlife and Plant Conservation Department of Marine and Coastal Resources
Annual change in carbon stocks in dead organic matter	Total area of natural forests converted to other land (ha)	Royal Forest Department Department of National Parks, Wildlife and Plant Conservation Department of Marine and Coastal Resources
4E Biomass Burning		
4E1 Forest Land Remaining Forest Land	Total area of natural forest burned (ha)	Royal Forest Department Department of National Parks, Wildlife and Plant Conservation
4E2 Land Converted to Cropland	Total area of natural forests converted to cropland (ha)	Royal Forest Department Department of National Parks, Wildlife and Plant Conservation Department of Marine and Coastal Resources
4E3 Land Converted to Other Land	Total area of natural forests converted to other land (ha)	Royal Forest Department Department of National Parks, Wildlife and Plant Conservation Department of Marine and Coastal Resources

Emission Factors

The country-specific emission factors (EFs) acquired from published data and expert judgment were used for most LULUCF categories. Except for non-CO_2 emissions from biomass burning, most of EFs were IPCC default. Sources of emission factors used in the LULUCF sector are summarized in Table 2-182.

Table 2-182: Sources of emission factors in the LULUCF sector

Category	Type of data	Data source
4. Land Use, Land-Use Change and Forestry		
4A Forest Land Remaining Forest Land		
Annual growth of forest plantations	Average annual above-ground biomass growth of forest trees (t DM/ha/yr)	Country specific emission factor, published by Kasetsart University Faculty of Forestry (2011)
	Root/shoot ratio (dimensionless)	Country specific emission factor, published by Kasetsart University Faculty of Forestry (2011)
	Carbon fraction (dimensionless)	Country specific emission factor, published by Kasetsart University Faculty of Forestry (2011)
Logging/harvesting in forest plantations	Above-ground biomass of harvested forest plantations (t DM/ha)	Country specific emission factor, published by Kasetsart University Faculty of Forestry (2011)
	Wood density (t/m3)	Country specific emission factor, published by Royal forest Department

Table 2-182: Sources of emission factors in the LULUCF sector (Cont'd)

Category	Type of data	Data source
Forest regrowth through forest restoration	Average annual above-ground biomass growth of forest restoration (t DM/ha/yr)	Country specific emission factor from publication
	Root/shoot ratio (dimensionless)	IPCC default
	Carbon fraction (dimensionless)	Country specific emission factor from publication
Forest regrowth through natural regeneration	Average annual above-ground biomass growth of forest restoration through natural regeneration (t DM/ha/yr)	Country specific emission factor from publication
Carbon losses due to biomass burning	Biomass fraction oxidized (dimensionless)	IPCC default
	Combustion factors for non-CO_2 gas	IPCC default
4B Cropland Remaining Cropland		
Annual growth of woody crops	Average annual above-ground biomass growth of rubber plantations (t DM/ha/yr)	Country specific emission factor, published by Kasetsart University Faculty of Forestry (2011)
	Root/shoot ratio (dimensionless)	Country specific emission factor, published by Kasetsart University Faculty of Forestry (2011)
	Carbon fraction (dimensionless)	Country specific emission factor, published by Kasetsart University Faculty of Forestry (2011)
Wood harvesting in woody crops	Above-ground biomass of harvested rubber plantations (t DM/ha)	Country specific emission factor, published by Kasetsart University Faculty of Forestry (2011)
	Wood density (t/m^3)	Country specific emission factor, published by Royal forest Department
4C Land Converted to Cropland		
Annual change in carbon stocks in biomass	Above-ground biomass of natural forest before conversion (t DM/ha)	Country specific emission factor, published by Kasetsart University Faculty of Forestry (2011)
	Above-ground biomass of natural forest after conversion (t DM/ha)	IPCC default
	Root/shoot ratio (dimensionless)	IPCC default
	Carbon fraction (dimensionless)	Country specific emission factor from publication
Annual change in carbon stocks in dead organic matter	Biomass fraction left to decay (dimensionless)	Country specific emission factor from publication

Table 2-182: Sources of emission factors in the LULUCF sector (Cont'd)

Category	Type of data	Data source
4D Land Converted to Other Land		
Annual change in carbon stocks in biomass	Above-ground biomass of natural forest before conversion (t DM/ha)	Country specific emission factor, published by Kasetsart University Faculty of Forestry (2011)
	Above-ground biomass of natural forest after conversion (t DM/ha)	IPCC default
	Root/shoot ratio (dimensionless)	IPCC default
	Carbon fraction (dimensionless)	Country specific emission factor from publication
Annual change in carbon stocks in dead organic matter	Biomass fraction left to decay (dimensionless)	Country specific emission factor from publication
4E Biomass Burning		
4E1 Forest Land Remaining Forest Land	Biomass fraction oxidized (dimensionless) Combustion factors for non-CO_2 gas	IPCC default
4E2 Land Converted to Cropland		
4E3 Land Converted to Other Land		

Emissions Tends in the LULUCF Sector for 2000-2022

The total CO_2 emissions and removals from carbon stock changes for each land use category is the sum of those from all land categories taking into account the three carbon pools: (i) above-ground biomass, (ii) below-ground biomass, and (iii) dead organic matter (deadwood and litter). The LULUCF sector in Thailand showed a trend of increased net removals because the total removals exceeded the total emissions (Figure 2-92). The non-CO_2 emissions including CH_4 and N_2O account for less than 1% of the overall country's emissions (Figure 2–93). The LULUCF activities contributed to a tremendous increase in net removals from the atmosphere since 2000 due to the net removal by cropland remaining cropland, followed by forest land remaining forest land. It can be observed that cropland dominates the net removals estimated for the LULUCF sector for Thailand. The GHG emissions tended to decrease after 2013, remained stable during 2014–2019 and increased during the last three years (2020–2022), mainly driven by the emissions from forest land conversions to other land uses. The total net removals fluctuated due to the significant change in the proportion of net removals from cropland remaining cropland between the base years and the current year. However, it appeared to remain stable after 2020. Changes in LULUCF emissions by land category during 2000-2022 are shown in Figure 2-94.

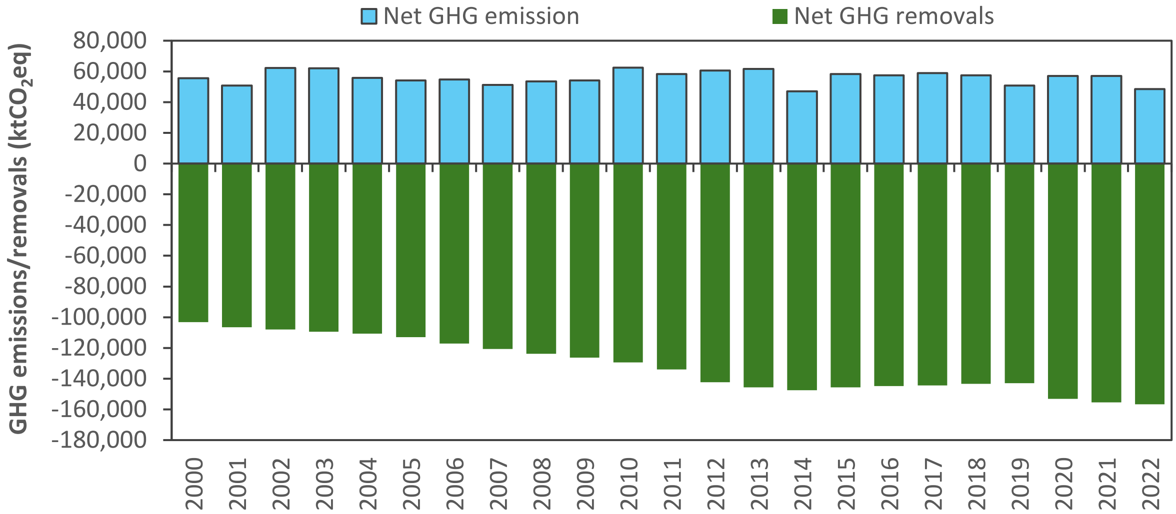


Figure 2-92: GHG emissions/removals in the LULUCF sector for 2000–2022

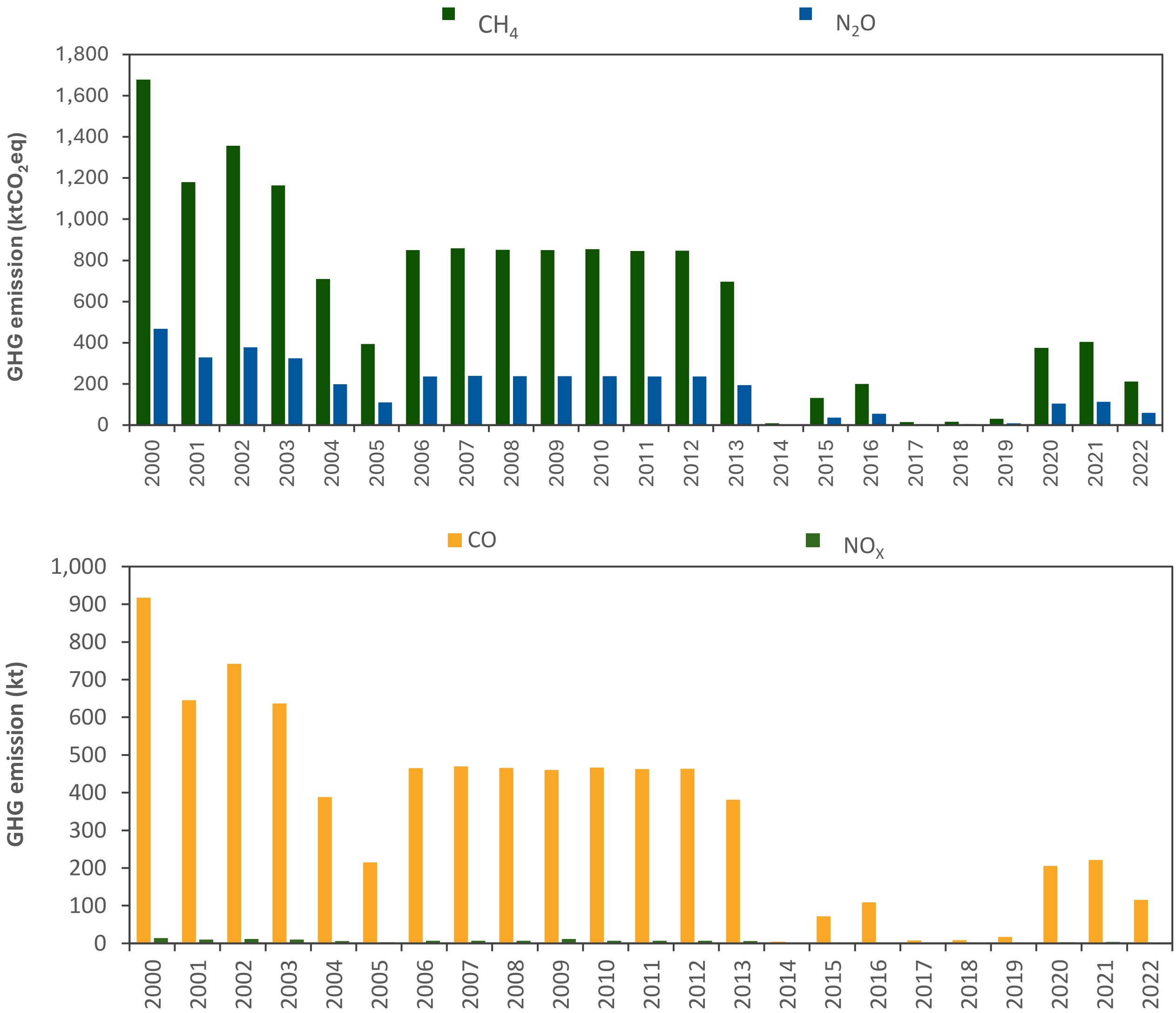


Figure 2-93: GHG emissions from non-CO_2 gases in the LULUCF sector for 2000–2022

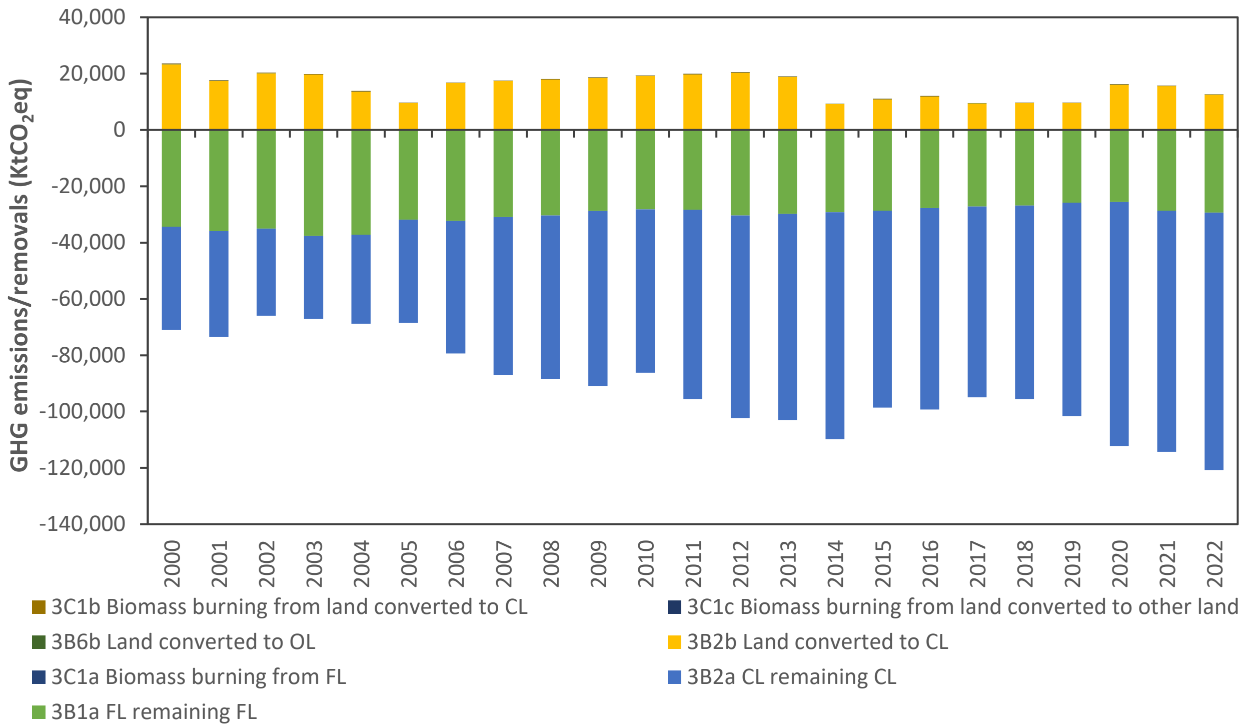


Figure 2-94: GHG emissions/removals in the LULUCF sector by land category for 2000–2022

Greenhouse Gas Emissions and Removals by subcategory for 2021-2022

In 2021, the LULUCF sector contributed to a net removal of 98,028.41 ktCO_2eq, an increase of approximately 53.77% compared with the year 2000. The net removal estimated for cropland remaining cropland was 85,614.81 ktCO_2eq, accounting for approximately 87.34% of overall net removals in this sector. The increased net removal was due to the decrease in losses of carbon from wood harvesting. The forest land remaining forest land contributed 28,635.83 ktCO_2eq, accounting for approximately 29.21% of overall net removals. On the other hand, forest land conversion produced 15,518.46 and 185.77 ktCO_2eq of GGH emissions from land converted to cropland and other land, respectively, thereby decreasing about 50% compared with the emissions in 2000. In addition, the non-CO_2 emissions calculated from biomass burning in the forest land remaining forest land and forest land conversion resulted in the emission of 517.99 ktCO_2eq. Details of GHG emissions/removals in the LULUCF sector by type of gas and source in 2021 are presented in Table 2-183 and Figure 2–95.

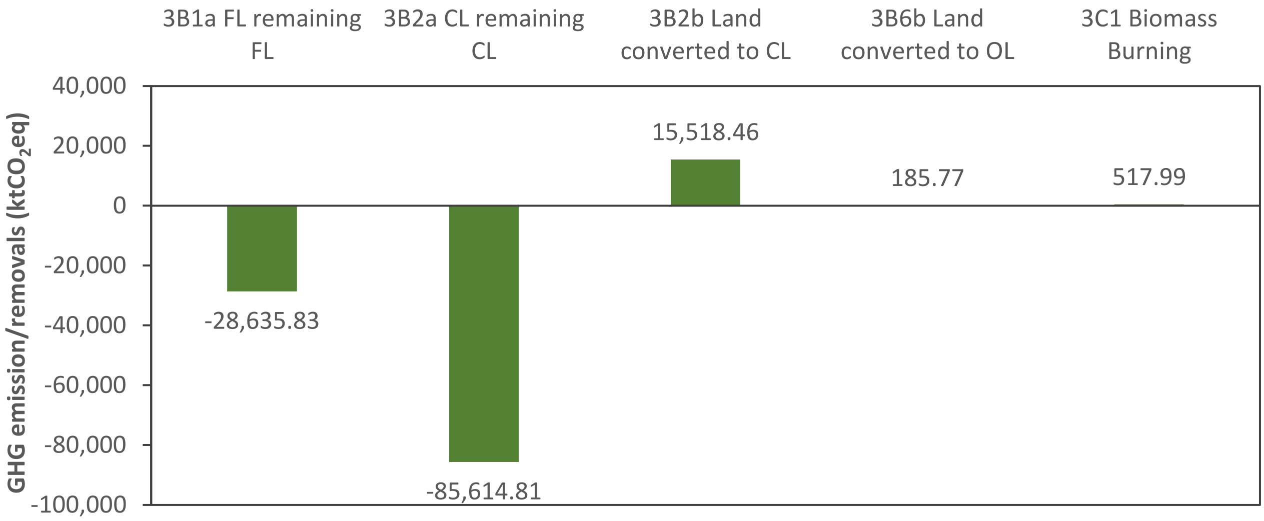


Figure 2-95: GHG emissions/removals in the LULUCF sector by subcategory in 2021

In 2022, the LULUCF sector contributed to a net removal of 107,901.43 ktCO_2eq, an increase of approximately 58.00 and 10.07% compared with the years 2000 and 2021, respectively. The net removal estimated for cropland remaining cropland increased to 91,486.96 ktCO_2eq, accounting for approximately 84.79% of overall net removals in this sector. The increased net removal was due to the decrease in losses of carbon from wood harvesting. The forest land remaining forest land contributed 29,328.06 ktCO_2eq, accounting for approximately 27.18% of overall net removals. On the other hand, forest land conversion reduced to 12,489.37 and 154.41 ktCO_2eq of GHG emissions from land converted to cropland and other land, respectively, thereby decreasing more than 50% compared with the emissions in 2000. In addition, the non-CO_2 emissions calculated from biomass burning in the forest land remaining forest land and forest land conversion resulted in the emission of 269.81 ktCO_2eq. Details of GHG emissions/removals in the LULUCF sector by types of gas and source in 2022 are presented in Table 2-184 and Figure 2–96.

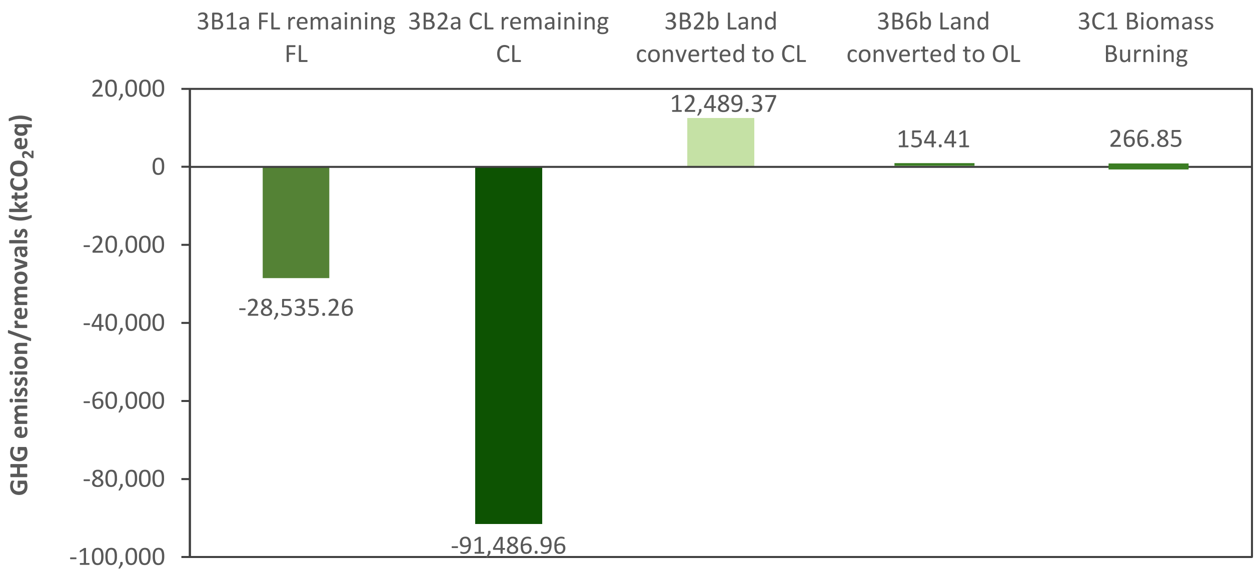


Figure 2-96: GHG emissions/removals in the LULUCF sector by subcategory in 2022

Table 2-183: GHG emissions/removals from sources relative to total emissions/removals in the LULUCF sector in 2021

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	Net	CH_4		NO_2		NOx	CO	NMVOCs	SO_2	HFCs	PFCs	SF_6	Total
Unit	$ktCO_2eq$	$ktCO_2eq$	$ktCO_2eq$	kt	$ktCO_2eq$	kt	$ktCO_2eq$	kt	kt	kt	kt	$ktCO_2eq$	$ktCO_2eq$	$ktCO_2eq$	$ktCO_2eq$
4. Land Use, Land-Use Change and Forestry	56,972.24	-155,518.64	-98,546.40	14.47	405.20	0.43	112.79	3.41	221.33	NO	NO	NO	NO	NO	-98,028.41
4A Forest Land Remaining Forest Land	19,411.58	-48,047.41	-28,635.83	NO		NO		NO	NO	NO	NO	NO	NO	NO	-28,635.83
4B Cropland Remaining Cropland	21,856.42	-107,471.23	-85,614.81	NO		NO		NO	NO	NO	NO	NO	NO	NO	-85,614.81
4C Land Converted to Cropland	15,518.46	NO	15,518.46	NO		NO		NO	NO	NO	NO	NO	NO	NO	15,518.46
4D Land Converted to Other Land	185.77	NO	185.77	NO		NO		NO	NO	NO	NO	NO	NO	NO	185.77
4E Biomass Burning	NO	NO	NO	14.47	405.20	0.43	112.79	3.41	221.33	NO	NO	NO	NO	NO	517.99
4E1 Forest Land Remaining Forest Land	NO	NO	NO	1.11	31.05	0.03	8.64	0.26	16.96	NO	NO	NO	NO	NO	39.70
4E2 Land Converted to Cropland	NO	NO	NO	13.21	369.88	0.40	102.96	3.11	202.04	NO	NO	NO	NO	NO	472.84
4E3 Land Converted to Other Land	NO	NO	NO	0.15	4.26	0.00	1.19	0.04	2.33	NO	NO	NO	NO	NO	5.45

Table 2-184: GHG emissions/removals from sources relative to total emissions/removals in the LULUCF sector in 2022

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	Net	CH_4		NO_2		NOx	CO	NMVOCs	SO_2	HFCs	PFCs	SF_6	Total
Unit	$ktCO_2eq$	$ktCO_2eq$	$ktCO_2eq$	kt	$ktCO_2eq$	kt	$ktCO_2eq$	kt	kt	kt	kt	$ktCO_2eq$	$ktCO_2eq$	$ktCO_2eq$	$ktCO_2eq$
4. Land Use, Land-Use Change and Forestry	48,610.77	-156,782.01	-108,171.23	7.54	211.06	0.22	58.75	1.77	115.28	NO	NO	NO	NO	NO	-107,901.43
4A Forest Land Remaining Forest Land	19,675.92	-49,003.98	-29,328.06	NO		NO		NO	NO	NO	NO	NO	NO	NO	-29,328.06
4B Cropland Remaining Cropland	16,291.07	-107,778.03	-91,486.96	NO		NO		NO	NO	NO	NO	NO	NO	NO	-91,486.96
4C Land Converted to Cropland	12,489.37	NO	12,489.37	NO		NO		NO	NO	NO	NO	NO	NO	NO	12,489.38
4D Land Converted to Other Land	154.41	NO	154.41	NO		NO		NO	NO	NO	NO	NO	NO	NO	154.41
4E Biomass Burning	NO	NO	NO	7.54	211.06	0.22	58.75	1.77	115.28	NO	NO	NO	NO	NO	269.81
4E1 Forest Land Remaining Forest Land	NO	NO	NO	0.29	8.24	0.01	2.29	0.07	4.50	NO	NO	NO	NO	NO	10.54
4E2 Land Converted to Cropland	NO	NO	NO	7.16	200.50	0.21	55.81	1.68	109.52	NO	NO	NO	NO	NO	256.31
4E3 Land Converted to Other Land	NO	NO	NO	0.08	2.39	0.00	0.64	0.02	2.26	NO	NO	NO	NO	NO	2.95

Forest Land Remaining Forest Land (4A): Thailand's forest land can be divided into two categories: natural forests and forest plantations. These categories are categorized by the group of tree species and forest type, respectively. In forest land remaining forest land, the major source of GHG emissions was harvesting in forest plantations, as logging was not permitted in natural forests. Additionally, carbon losses resulting from biomass combustion during annual wildfires in natural forests have been reported. The annual growth of forest plantations and the regrowth of natural forests were used to calculate the GHG removals. Forest regrowth was defined as approximately 33% of the total forest area, which was achieved through natural regeneration and forest restoration. Consistent with the IPCC 2006 guidelines, the carbon stock of the remaining natural forests was assumed to be relatively stable, with no emissions or removals. Overall, the forest land remaining forest land has provided a net removal of CO_2 throughout the years 2000-2022 (Figure 2-97). The sequestration from natural regeneration and forest plantations, accounting for more than 90% of the total removals, generally outweighed emissions from logging in forest plantations and burning activities in natural forests. The stability in removals over the years suggests that forest management practices supporting natural regeneration and plantation growth play a critical role in maintaining CO_2 removals in forest land.

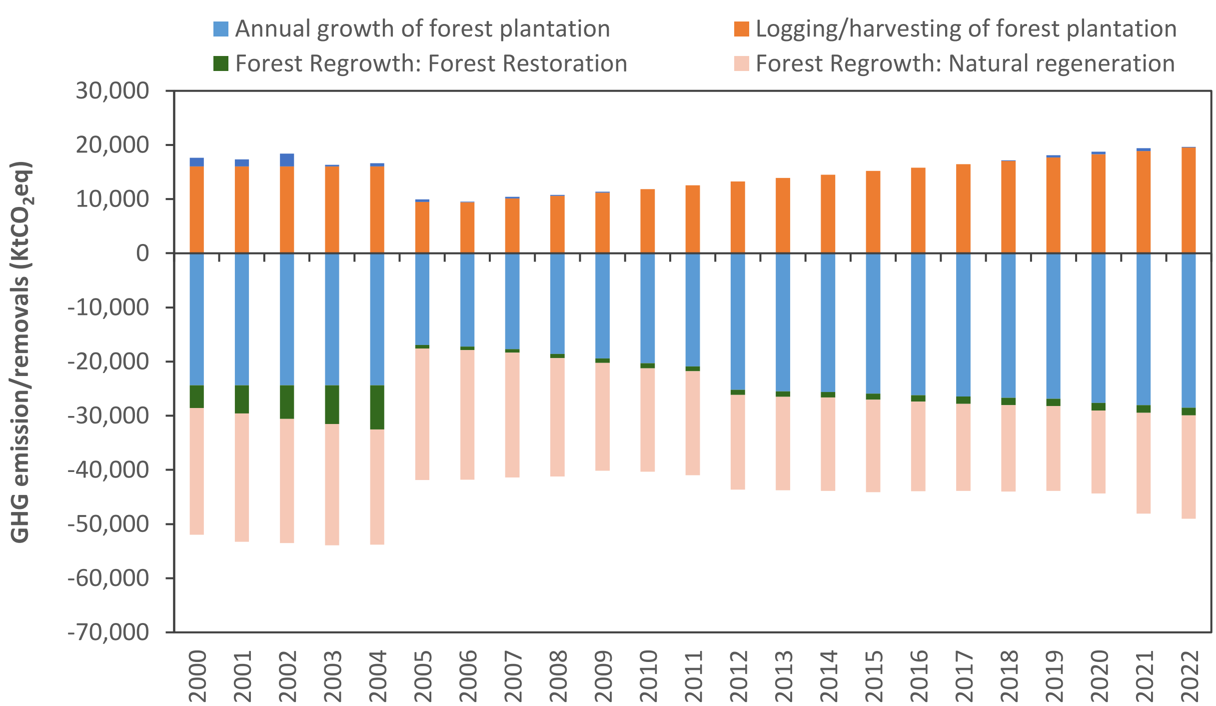


Figure 2-97: GHG emissions/removals in the LULUCF sector, forest land remaining forest land subcategory for 2000-2022

Cropland Remaining Cropland (4B): The rubber tree, oil palm, and fruit trees are the primary woody perennial crops in Thailand. Since there was inadequate activity data for wood harvesting of other species, the GHG emissions and removals from cropland remaining cropland have been reported exclusively on rubber plantations from 2000 to 2021. The net removal from rubber plantations accounted for more than 80% of overall net removals in this sector during the last few years. Despite periodic wood removals over a 25-year period, rubber plantations consistently exhibited significant carbon sequestration. Conversely, annual CO_2 emissions resulting from harvesting activities in rubber plantations were relatively low, about 25% of CO_2 removals (Figure 2-98). The overall trend has been relatively stable, with rubber plantations continuing to provide net carbon removals over the 2000–2021 period because of the combination of carbon sequestration from tree growth and emissions from harvesting. The preparation of accurate data regarding periodic timber harvesting, carbon sequestration, and emissions factors of additional woody crops, such as oil palm and fruit trees, is presently underway to establish a more comprehensive GHG inventory for woody cropland in future reports.

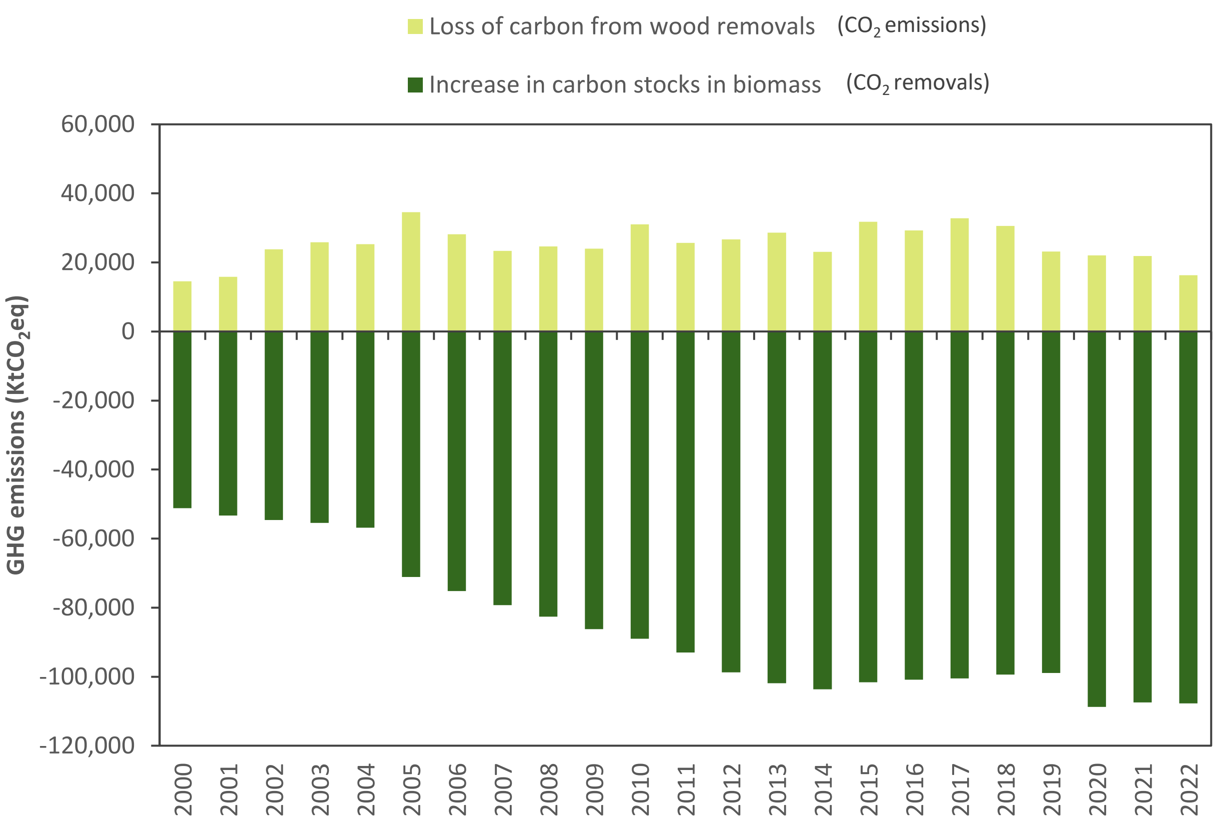


Figure 2-98: GHG emissions/removals in the LULUCF sector, cropland remaining cropland subcategory for 2000-2022

Land Converted to Cropland (4C) and Land Converted to Other Land (4D): The GHG emissions resulting from the conversion of forest land to cropland and other land from 2000 to 2021 were reported in these two subcategories. These emissions stem from the loss of carbon stored in forest biomass and the release of carbon from decaying dead organic matter (DOM), following the shift in land use. Emissions from forest converted to cropland were initially high from 2000 to 2004, decreased after 2004, and remained relatively steady until 2017. After 2017, there was a slight increase in emissions due to cropland conversion, though still lower than the early 2000s (Figure 2-99). However, the general decline in emissions since the early 2000s may reflect improved forest management practices, reductions in deforestation rates, or policy interventions to limit land-use change.

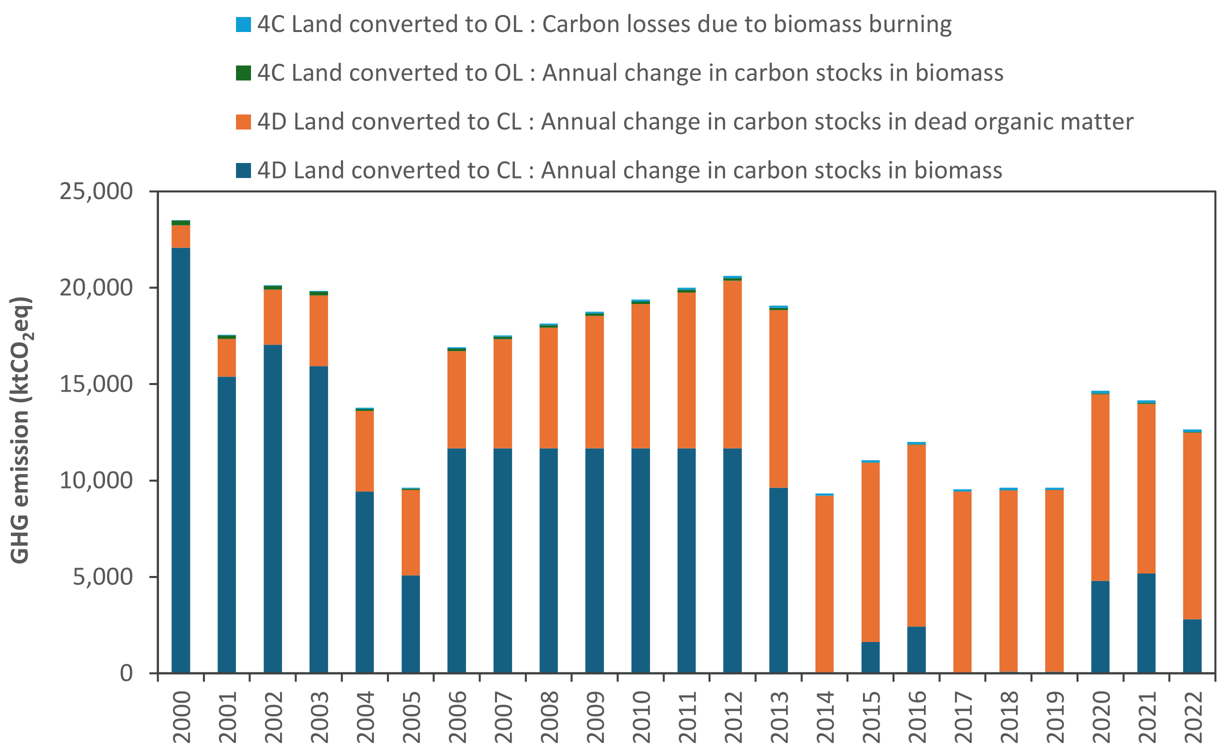


Figure 2-99: GHG emissions/removals in the LULUCF sector, land converted to cropland and land converted to other land subcategory for 2000-2022

Biomass Burning (4E): In the LULUCF sector, non-CO_2 emissions, including CH_4, N_2O, NOx and CO were estimated from biomass burning from an uncontrolled forest fire in natural forest (4E1 biomass burning from forest land remaining forest land), forest converted to cropland (4E2 biomass burning land converted to cropland), and land converted to other lands (4E3 biomass burning from land converted to other land). Only CH_4 and N_2O emissions were converted to CO2 emissions equivalent. The emission level from all non-CO_2 sources fluctuated significantly, with the greatest level being recorded in 2000. There was a general decrease in emissions from 2000 to 2005. A general stabilization of emissions occurred after 2005, but intermittent fluctuations were observed, with significant decreases in 2014 and 2017. Compared to N_2O, CH_4 emissions were a significant contributor to GHG emissions from biomass burning (Figure 2-100). The CO_2 emission trend from forest land conversion was consistent with the on-site and off-site biomass burning that appeared to be an important contributing factor to non-CO_2 emissions.

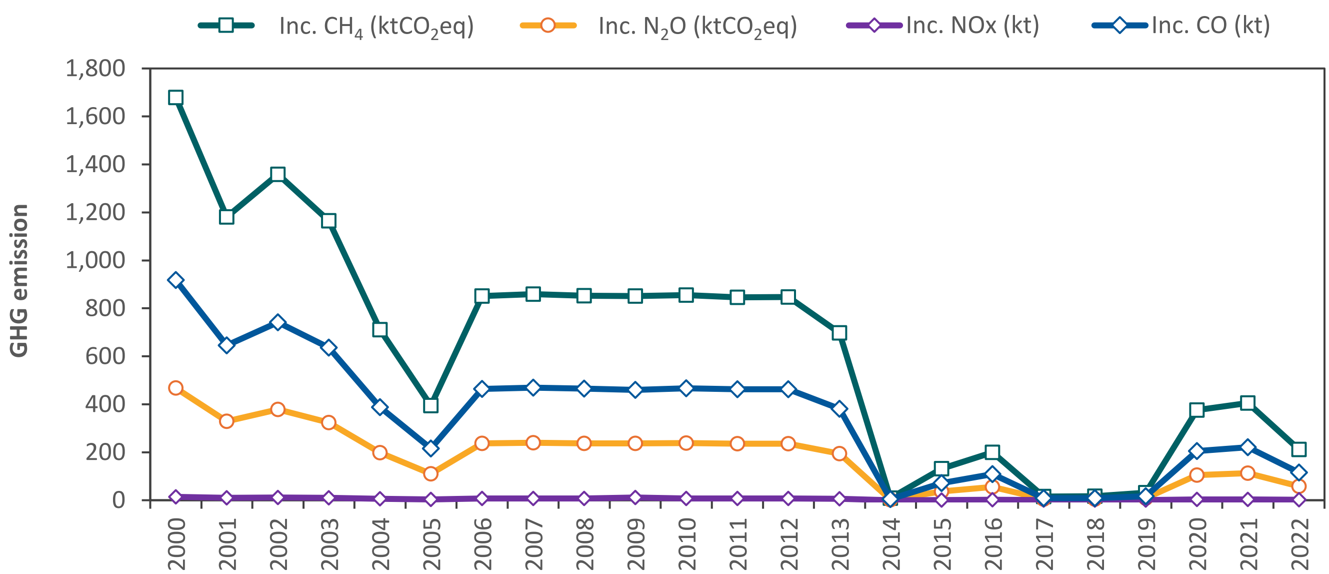


Figure 2-100: GHG emissions/removals in the LULUCF sector, biomass burning subcategory for 2000-2022

Uncertainty Analysis of LULUCF Sector

The greenhouse gas inventory for the LULUCF sector was prepared in accordance with Good Practice Guidance for Land Use, Land–use Change and Forestry (IPCC, 2003), which typically contains a wide range of emission calculations. The uncertainty analysis revealed that the overall uncertainty of Thailand's national GHG inventory in LULUCF sector was approximately 79.99% in 2000 and 63.77, 61.88 and 56.09% during 2020-2022, respectively (Figure 2-101). Due to the greatest removals, the uncertainties derived from Cropland Remaining Cropland contributed significantly to the overall uncertainties in the LULUCF sector.

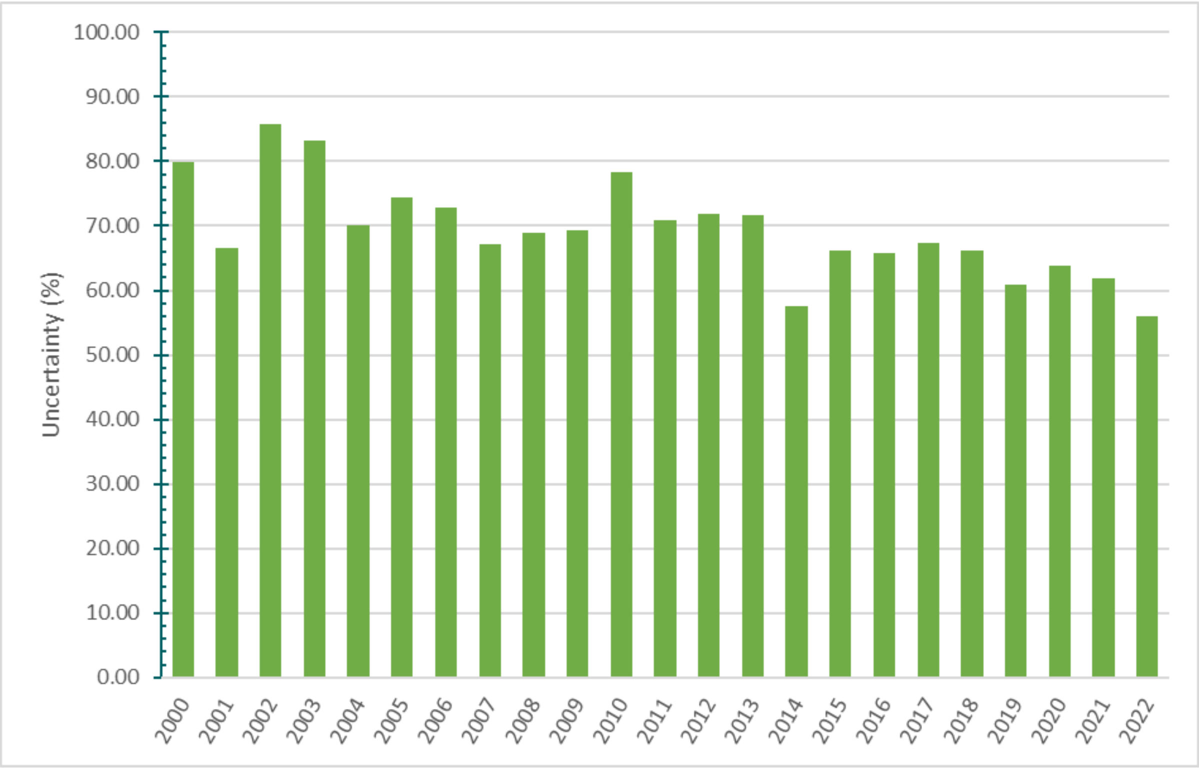


Figure 2-101: Uncertainties of the GHG inventory in the LULUCF Sector for 2000-2022

Recalculation of LULUCF Sector

The Third Biennial Update Report's (BUR3) inventories were the first to be calculated using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Subsequently, the Fourth Biennial Update Report's (BUR4) inventories followed the 2006 IPCC Guidelines and activity data, and country specific data were updated, including the annual increment in aboveground biomass of woody crops and the annual changes in carbon stocks of dead wood and litter (DOM). The emissions for the period 2000–2016 were recalculated with the updated activity data and revised emission factors to establish consistency for the years 2000 and 2019. In this inventory submission, the Biennial Transparency Report (BTR) inventories for 2020–2022 were prepared following the 2006 IPCC Guidelines and applying the same country-specific data as BUR4. However, global warming potential (GWP) for non-CO_2 gases including CH_4 and N_2O was updated from AR4 to AR5. Recalculations for previous inventories (2000–2019) were required to maintain consistency for the 2000–2021 period (Figure 2-102). The differences between the net removals reported in BTR and those reported in BUR4 during 2000-2022 were less than 1%. The development to improve accuracy and transparency of country-specific data—including annual increment of aboveground biomass of forest trees, woody crops, natural forests, and annual biomass growth in natural forests—are currently in progress and are anticipated to be completed by early 2025. The integration of activity data and country-specific emission factors from Forest Reference Level (FRL) and Forest Reference Emission Level (FREL) of REDD+ for national GHG inventory is also in progress.

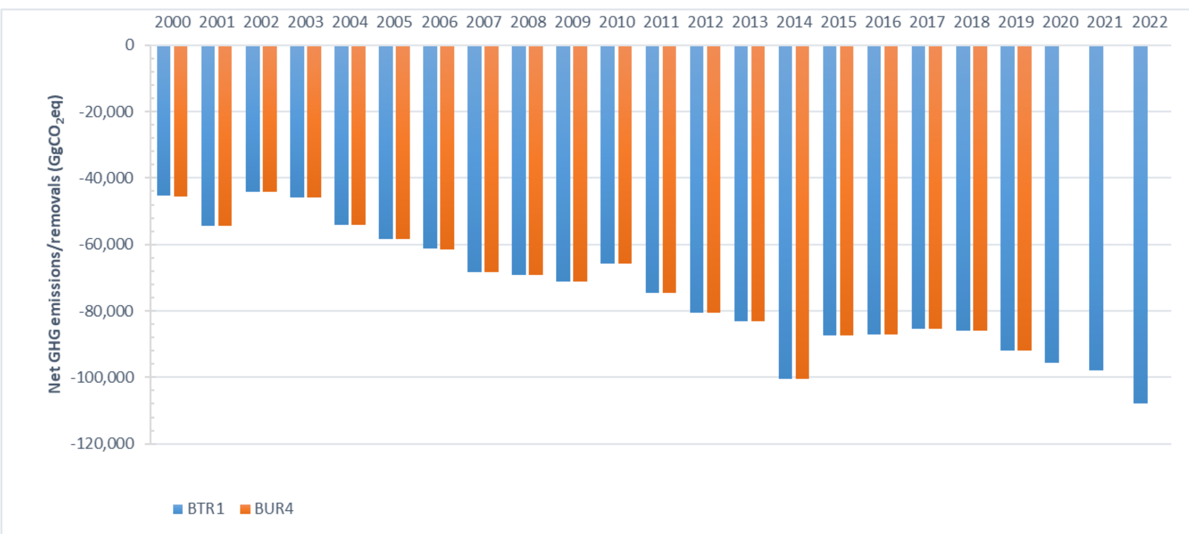


Figure 2-102: Recalculations of the GHG inventory in the LULUCF Sector for 2000-2022

Chapter III

INFORMATION NECESSARY TO TRACK PROGRESS MADE IN IMPLEMENTING AND ACHIEVING NATIONALLY DETERMINED CONTRIBUTIONS UNDER ARTICLE 4 OF THE PARIS AGREEMENT

CHAPTER 3

INFORMATION NECESSARY TO TRACK PROGRESS MADE IN IMPLEMENTING AND ACHIEVING NATIONALLY DETERMINED CONTRIBUTIONS UNDER ARTICLE 4 OF THE PARIS AGREEMENT

This Chapter provides information necessary to track progress made in implementing and achieving nationally determined contributions under Article 4 of the Paris Agreement. The National circumstances and institutional arrangements have been described in Chapter 1. Section 3.1 describes information on Thailand's nationally determined contribution under Article 4 of the Paris Agreement, including updates. Sections 3.2.1 and 3.2.2 describe information necessary to track progress made in implementing and achieving its nationally determined contribution under Article 4 of the Paris Agreement. Section 3.2.3 describes mitigation policies and measures, actions and plans, related to implementing and achieving a nationally determined contribution under Article 4 of the Paris Agreement. Finally, Section 3.3 describes the use of cooperative approaches involving Internationally Transferred Mitigation Outcomes (ITMOs) towards NDCs under Article 6 of the Paris Agreement.

3.1 DESCRIPTION OF NATIONALLY DETERMINED CONTRIBUTION UNDER ARTICLE 4 OF THE PARIS AGREEMENT

Thailand communicated its first generation of Nationally Determined Contribution (NDC 1.0) in 2015 to reduce GHG emissions by 20 – 25 percent against the BAU level by 2030. At the World Leader Summit COP26 on 1 November 2021, Thailand's Prime Minister expressed Thailand's intention to fully elevate climate mitigation measures. Thailand aims to achieve Carbon Neutrality by 2050 and Net-Zero Greenhouse Gas Emissions by 2065.

Furthermore, Thailand intends to reduce its GHG emissions by 30 percent from the projected business-as-usual (BAU) level (at 555 $MtCO_2eq$) by 2030. The level of contribution could increase up to 40 percent, subject to adequate and enhanced access to technology development and transfer, financial resources and capacity building support. The timeframe of its implementation is 2021-2030 with a single year target in 2030 and covering economy-wide sectors (excluding land use, land-use change, and forestry) and six GHGs (Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF_6)) (Figure 3-1).

Based on a more ambitious pledge, Thailand has revised and updated its NDC, now referred to as the second generation (NDC 2.0). The document submitted to the UNFCCC can be found at https://unfccc.int/documents/638001. Additionally, the Long-Term Low Greenhouse Gas Emission Development Strategy (LT-LEDs) has been updated to reflect national targets on carbon neutrality 2050 in line with the Prime Minister's statement. The revised document submitted to the UNFCCC can be found at https://unfccc.int/documents/622276.

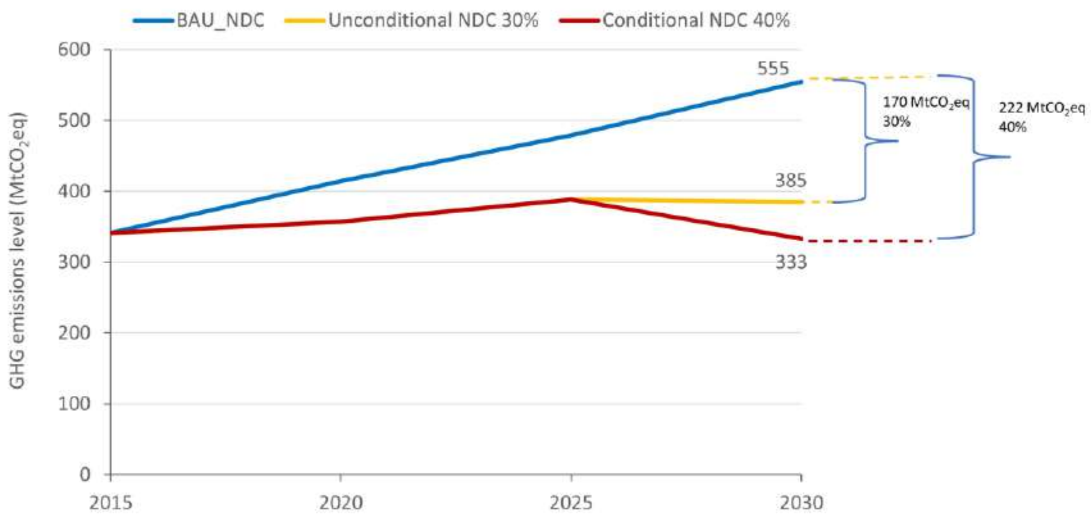


Figure 3-1: Projection of GHG emissions under BAU and implementing NDC in 2030

Thailand's LT-LEDs and the Second Updated NDC have been developed in alignment with national and sectoral policies, plans, and carbon neutrality 2050 as follows:

- 20-Year National Strategy 2018-2037
- Climate Change Master Plan 2015-2050
- Thailand Nationally Determined Contribution (NDC) 2021-2030
- National Energy Plan 2022
- Energy Efficiency Plan 2018-2037 (EEP 2018)
- Alternative Energy Development Plan 2018-2037 (AEDP 2018)
- Power Development Plan 2018-2037 (PDP 2018 Rev.1)
- The guideline for promoting electric vehicles (EV) under policy 30@30
- National Industrial Development Master Plan 2012-2031
- Industrial Development Strategy of Thailand 4.0 2017-2036
- Thailand Forest Reference Emission Level and Forest Reference Level REDD+ under the UNFCCC
- 20-Year Strategy of the Royal Forest Department 2017-2036
- 20-Year Agriculture and Cooperative Strategy 2017–2036

In the Second Updated NDC, the agriculture sector was included for the first time, with the following reduction measures:

- Energy and transport sector: The energy sector is the sector with the most significant potential to reduce greenhouse gas emissions. It includes measures to increase the energy efficiency of equipment/machines in power plants and renewable energy utilization.
- IPPU sector, comprising clinker substitution measures and refrigerant replacement

- Waste management sector consists of municipal solid waste management, municipal wastewater management, and industrial wastewater management.
- Agriculture sector consists of fixed dome digester biogas production measures and improvements in rice farming to reduce methane emissions.

The implementation of Thailand's Long-Term Low Greenhouse Gas Emission Development Strategy is in accordance with Article 4 of the Paris Agreement, which requires all countries to develop and communicate a long-term strategy for low GHG emission development to the UNFCCC Secretariat aiming to limit global temperature from rising above 2 °C or 1.5 °C. Thailand has set long-term targets and guidelines for GHG reduction toward carbon neutrality by 2050 and net-zero emission in 2065 by identifying key measures in the sectors of energy, transport, IPPU, waste, agriculture, and LULUCF, which is the GHG removal sector of the country, for relevant agencies and sectors to use as operational guidelines. The revised LT-LEDS and the second updated NDC documents submitted to UNFCCC in 2022, were supported by the Deutsche Gesellshaft für Internationale Zusammenarbeit (GIZ) GmbH. The revised LT-LEDS sets goals and measures aligning with an increase in global average temperatures of 1.5 °C and moving toward carbon neutrality by 2050. The analyses employ the end-use approach of the Asia-Pacific Integrated Assessment Model (AIM) to project the long-term low-level greenhouse gas emissions, including remedial policy measures for climate change adaptation action, and using the computable general equilibrium model of the AIM model to assess the economic and environmental impacts of energy policy and others in the development of LT-LEDS. The methodology for both NDCs and LT-LEDS can be found at (https://www-iam.nies.go.jp/aim/pdf/Thailand_Net_Zero_2050_Roadmap_v2.pdf)

After the submission of updated NDC to the UNFCCC in 2022, Thailand developed an economy-wide NDC action plan with details of the workplans in Energy, Transport, IPPU, Agriculture and Waste sectors. The NDC Action Plan on Mitigation 2021–2030 is the key milestone of Thailand for achievement of GHG emissions reduction targets in 2030. According to the institutional arrangement on climate change of Thailand, the Action Plan 2030 of the unconditional NDC was approved by the sub-committee under MONRE and National Climate Change Committee. Table 3-1 summarizes sectoral GHG emissions reduction targets of Thailand's NDC Action Plan on Mitigation 2021–2030.

Table 3-1: Sectoral GHG emissions reduction targets of the NDC Action Plan on Mitigation 2021–2030

<table>
<tr><th rowspan="4">Sector</th><th colspan="6">GHG mitigation target in 2030</th></tr>
<tr><th colspan="2" rowspan="2">Unconditional NDC</th><th colspan="4">Conditional NDC</th></tr>
<tr><th colspan="2">In process</th><th colspan="2">Support needed</th></tr>
<tr><th>$MtCO_2eq$</th><th>%</th><th>$MtCO_2eq$</th><th>%</th><th>$MtCO_2eq$</th><th>%</th></tr>
<tr><td>Energy</td><td>124.6</td><td>22.5</td><td>-</td><td>-</td><td>32.0</td><td>5.8</td></tr>
<tr><td>Transport</td><td>45.6</td><td>8.2</td><td>-</td><td>-</td><td>2.50</td><td>0.4</td></tr>
<tr><td>Waste</td><td>9.1</td><td>1.6</td><td>-</td><td>-</td><td rowspan="3">1.9</td><td rowspan="3">0.3</td></tr>
<tr><td>IPPU</td><td>1.4</td><td>0.3</td><td>0.1</td><td>0.02</td></tr>
<tr><td>Agriculture</td><td>4.1</td><td>0.7</td><td>1.0</td><td>0.18</td></tr>
<tr><td rowspan="3">Total</td><td rowspan="2">184.8</td><td rowspan="2">33.3</td><td>1.1</td><td>0.2</td><td>36.40</td><td>6.5</td></tr>
<tr><td colspan="4">37.5 $MtCO_2eq$ or 6.7%</td></tr>
<tr><td colspan="6">222.3 or 40%</td></tr>
</table>

3.2 INFORMATION NECESSARY TO TRACK PROGRESS MADE IN IMPLEMENTING AND ACHIEVING ITS NATIONALLY DETERMINED CONTRIBUTION UNDER ARTICLE 4 OF THE PARIS AGREEMENT

In support of the unconditional NDC implementation, Thailand developed its climate mitigation action plan (NDC Action Plan on Mitigation 2021 – 2030). This plan outlines the mandate for various entities, including the identification of activities, GHG emission reduction targets, budget allocations, implementation timelines, and the relevant agencies in each sector. The plan aims to achieve a 30 percent reduction with domestic efforts and an additional 10 percent reduction through international support, under the conditional target. The targeted sectors are Energy, Transport, IPPU, Waste, and Agriculture. In addition, Thailand views cooperative approaches under Article 6 of the Paris Agreement as an opportunity to enhance the implementation of its conditional NDCs. The greenhouse gas reduction of the unconditional NDCs through domestic operations consists of five sectors, including:

Energy Sector

The implementation of greenhouse gas reduction measures in the energy sector consists of actions under three groups of measures: Energy conservation and increase in energy efficiency in generating electricity group, Alternative Energy group, and Measures of technology in capturing and storing carbon dioxide group. The implementation of greenhouse gas reduction measures in the energy sector is designated as part of the operations under the (draft) National Energy Plan B.E. 2566 (2023). The details of the measures are as follows:

1) Energy conservation and increase in energy efficiency in generating electricity group
    - 1.1) Enforcing measures to conserve energy in factories and controlled buildings
    - 1.2) Enforcing new building standards to conserve energy
    - 1.3) Determining standard labeling for machinery and materials to conserve energy
    - 1.4) Enforcing using standard criteria in conserving energy for producers and distributing energy/ Energy Efficiency Resources (EERS)
    - 1.5) Supporting projects relating to energy conservation
    - 1.6) Increasing efficiency in energy production
2) Alternative Energy group
    - 2.1) Development of wind energy
    - 2.2) Development of solar energy
    - 2.3) Development of hydropower
    - 2.4) Development of biomass energy
    - 2.5) Development of biogas
    - 2.6) Development of waste to energy
    - 2.7) Development of ethanol
    - 2.8) Development of biodiesel

2.9) Development of new clean energy

3) Measures of technology in capturing and storing carbon dioxide

3.1) Pilot projects in capturing and storing CO_2 at the Arthit, the natural gas site

Transport Sector

The implementation of greenhouse gas reduction measures in the transport sector consists of actions under six groups of measures: Group of measures in supporting the use of electric vehicles (Electrification of Transport), Group of measures in improving energy efficiency (Energy Efficiency Improvement), Group of measures in improving urban mobility, Group of measures in improving inter-urban transport and green logistics, Group of Measures in supporting alternative future energy for transport, and Group of Measures in developing basic infrastructure and transport sector (Transport Infrastructure and Support). The details of the measures are as follows:

1) Group of measures in supporting the use of electric vehicles (Electrification of Transport)

1.1) Promoting the adoption of EV

1.2) Promoting the use of electric locomotives

1.3) Promoting the use of electric boats

1.4) Promoting of infrastructure supporting EVs

2) Group of measures in improving energy efficiency (Energy Efficiency Improvement)

2.1) Setting standards and providing information on energy efficiency and greenhouse gas emissions

2.2) Improving the tax system to encourage the use of energy-efficient vehicles

3) Group of measures in improving urban mobility

3.1) Improving public transportation infrastructure

3.2) Promoting shared mobility and multi-model transport

3.3) Managing traffic in the cities

4) Group of measures in improving inter-urban transport and green logistics

4.1) Development of rail transportation infrastructure

4.2) Improvement in efficiency of water transportation

4.3) Promotion of logistic management

5) Group of Measures in supporting alternative future energy for transport

5.1) Promoting the use of hydrogen for transportation (start operating after 2030)

5.2) Promoting Sustainable Aviation Fuel (SAF) at the airport (under MOEN and supporting its usage, especially for international air transport)

6) Group of Measures in developing basic infrastructure and transport sector (Transport Infrastructure and support)

    6.1) Development of environmentally friendly transport infrastructure

    6.2) Development of basic infrastructure supporting transport efficiency

Industrial Processes and Product Use sector

The implementation of greenhouse gas reduction measures in the Industrial Processes and Product Use (IPPU) sector consists of actions under two groups of measures: Group of measures in replacing clinker and Group of measures in replacing/changing refrigerants. The details of the measures are as follows:

1) Group of measures in replacing clinker

    1.1) The use of alternative materials to replace clinker in the production of hydraulic cement

    1.2) The use of alternative materials to replace cement in ready-mixed concrete

2) Group of measures in replacing/changing refrigerants

    2.1) Modifying refrigeration system under the RAC NAMA (Refrigeration and Air Conditioning Nationally Appropriate Mitigation Actions) Project

    2.2) Disposing of refrigerants and the management of refrigeration systems in accordance with regulations

Agricultural sector

The implementation of greenhouse gas reduction measures in the agricultural sector consists of actions under three measures: waste management measures in the livestock sector, measures to reduce the use of chemical fertilizers, and measures for alternate wet and dry rice cultivation.

Waste Management and Industrial Wastewater sector

The implementation of greenhouse gas reduction measures in the waste management and industrial wastewater sector consists of actions under four groups of measures: Group of measures in managing community waste, Group of measures in wastewater management in the community, Group of measures in industrial wastewater management, and Group of measures in promoting GHG reduction in the communities and industrial wastewater. The details of the measures are as follows:

1) Group of measures in managing community waste

    1.1) Burning landfill gas or using kit for electricity generation

    1.2) Waste to energy for electricity generation

    1.3) Semi aerobic landfill

    1.4) Composting and bio-extract

    1.5) Anaerobic digestion

    1.6) Mechanical biological treatment

2) Group of measures in wastewater management in the community

    2.1) Increase integration of wastewater into the system and increase system units in treating wastewater from the community

3) Group of measures in industrial wastewater management

    3.1) Increasing the production of biogas from industrial wastewater by reusing methane gas

4) Group of measures in promoting GHG reduction in the communities and industrial wastewater/increasing the use of municipal waste/stop open burning of waste/community wastewater management/reducing the amount of community wastewater at the source/utilizing wastewater and sludge from community wastewater treatment systems/developing a system for assessing greenhouse gas emissions

    4.1) Reducing the amount of plastic waste, such as single-use plastics and food packing foam

    4.2) Reducing the amount of organic waste

    4.3) Promoting eco-friendly products and services

    4.4) Encouraging the production of products following the circular economy principles through carbon footprint certification

    4.5) Sorting municipal waste at the source for recycling

    4.6) Utilizing organic waste at the source, such as for animal feed, composting, and biogas production

    4.7) Stopping open burning of waste

    4.8) Promoting the production and use of water-saving products

    4.9) Promoting the production and use of wastewater treatment products with high-efficiency labels

    4.10) Encouraging Local Administrative Organizations (LAOs) to reuse treated wastewater for their own operations and for private sector use

    4.11) Utilizing sludge from wastewater treatment systems

    4.12) Developing a system for data collection regarding the amount of GHG from relevant agencies

The NDC action plan mentions not only the direct mitigation measures and numeric outcomes, but also the enabling environment as an important part of the implementation. This includes supportive measures to facilitate and accelerate the actions such as the formulation of laws and regulations, the development of economic tools and mechanisms, capacity building, research and technology development, and the preparation of implementation in the long-run. The NDC Action Plan on Mitigation 2021–2023 was approved by the Cabinet on December 11, 2024. Once approved, it serves as the official framework for Thailand's climate mitigation efforts, guiding the implementation of sector-specific actions and ensuring alignment with both domestic and international climate goals.

3.2.1 Indicators to Track Progress towards the Implementation and Achievement of NDC

This section provides necessary information on indicators to track progress towards the implementation and achievement of the implemented NDC of Thailand, in accordance with 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). The indicators to track progress of the implemented unconditional NDC are described in this section.

The indicators to track progress towards the implementation and achievement of its NDC under Article 4 for Thailand are based on Business-as Usual (BAU). The baseline emissions under BAU or without measures (WOM) are projected to 2030 using 2015 as a base year. GHG emissions reduction of the implementing NDC are quantified using the CO_2 countermeasures/actions described in Section 3.1. As presented in Table 3-1, an unconditional NDC target of 184.8 $MtCO_2eq$ (33.3%) will be achieved by domestic resources and capacity, called "unconditional NDCs", while an additional 6.7% of emissions reduction in BAU 2030 (37.5 $MtCO_2eq$), called "conditional NDCs", needs support. Figures 3-2 and 3-3 show indicators for achievement of the unconditional NDC for 2021-2030 by reduction percentage and quantities, respectively.

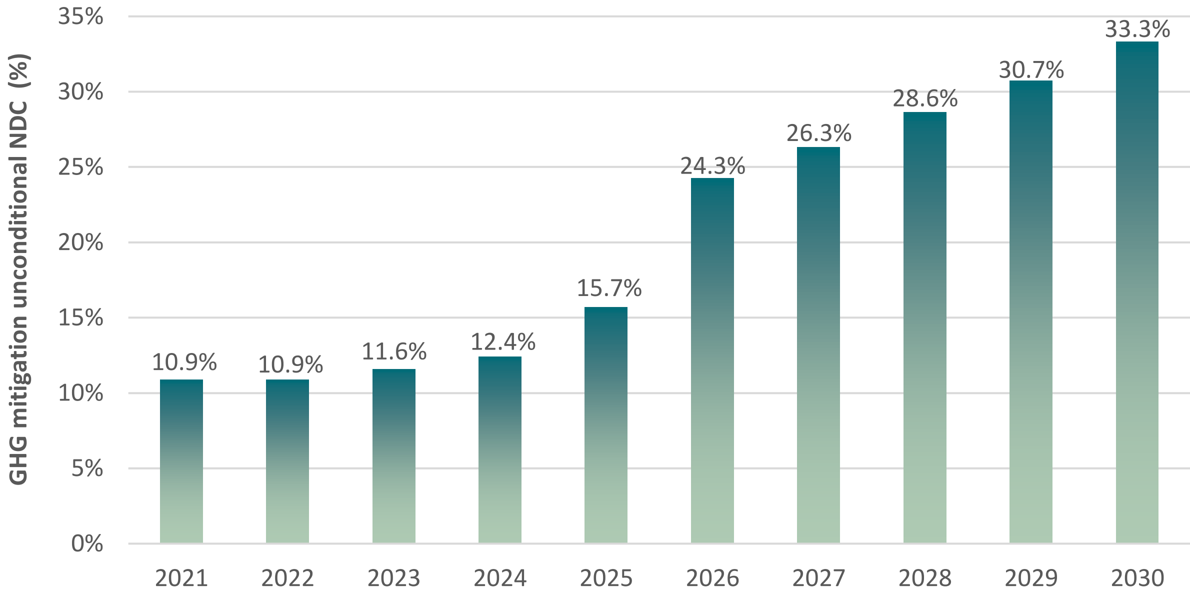


Figure 3-2: Indicator by percent reduction relative to the BAU for tracking progress of implemented unconditional NDC

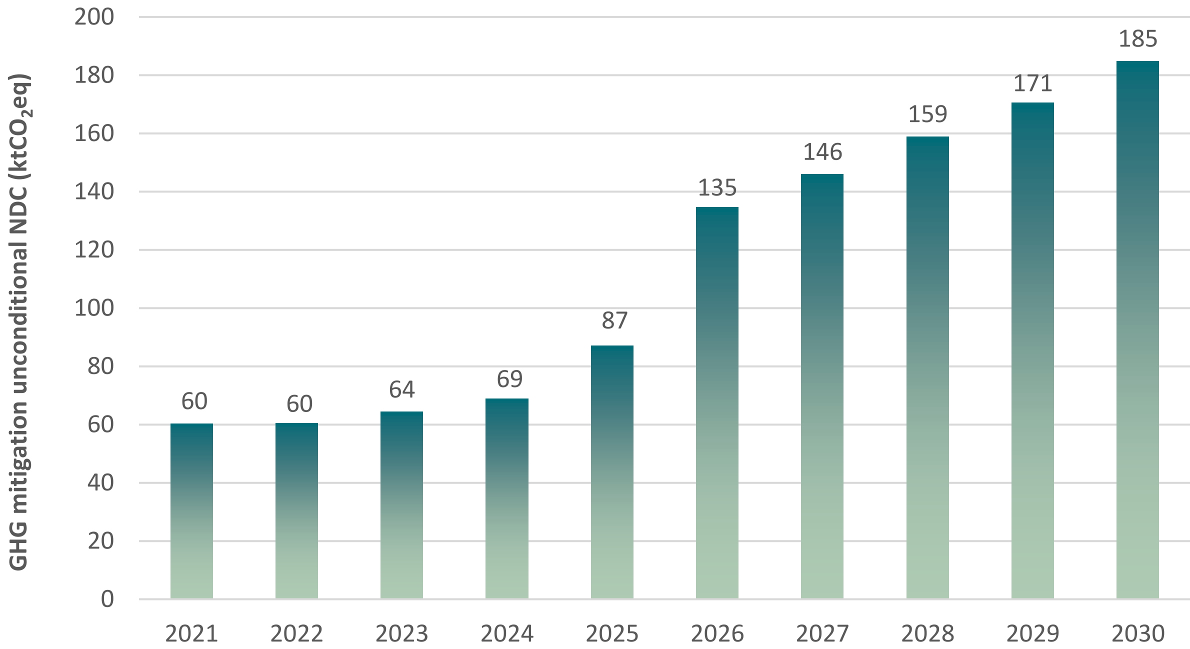


Figure 3-3: Indicator by CO_2eq reduction relative to the BAU for tracking progress of implemented unconditional NDC

Both indicators in terms of percentage reduction and reduction in CO_2eq are relevant to Business-as Usual (BAU) of Thailand's NDCs, and both indicators are used for tracking progress made in implementing and achieving the unconditional NDC of Thailand under Article 4 of the Paris Agreement.

Information on Indicators for Tracking Progress of Unconditional NDC

- Baseline is the Business-as Usual (BAU).
- The reference point is the emissions in the BAU 2030 at GHG emissions level of 555 $MtCO_2$eq.
- The base year is 2020, and it is the starting point of emissions reduction of implemented NDC.

Projections of GHG emissions reduction and achievement of unconditional NDCs are presented in Figure 3-4, and projections of GHG emissions reduction and achievement of its NDCs in each sector are shown in Figures 3-5 to 3-8. The projections of emissions reductions for 2021-2030 of the unconditional NDCs were developed and provided by the line ministries responsible for the implementation of NDCs. They are Ministry of Energy (Energy sector), Ministry of Transport (Transport sector), Ministry of Industry (IPPU sector), Ministry of Agriculture and Cooperatives (Agriculture sector), and Ministry of National Resources and Environment (Waste sector).

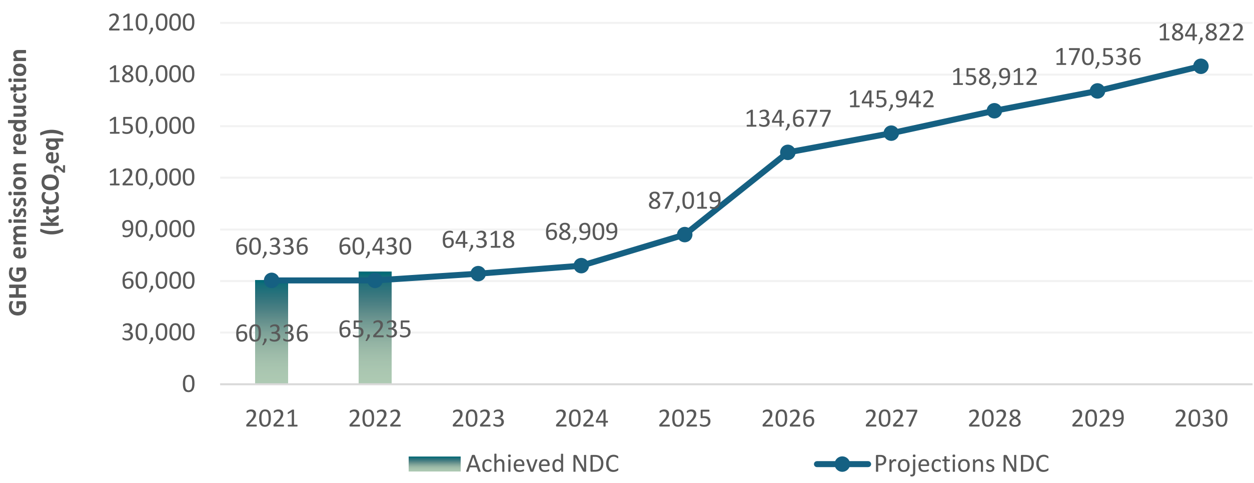


Figure 3-4: Projections of GHG emissions reduction and achievement of unconditional NDCs

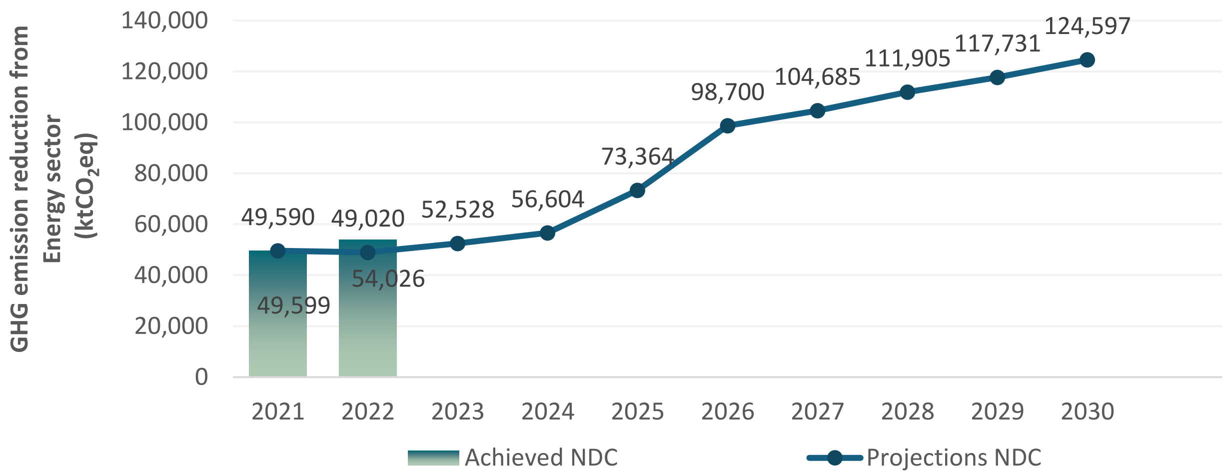


Figure 3-5: Projections of emissions reduction and achievement of NDC in the Energy sector

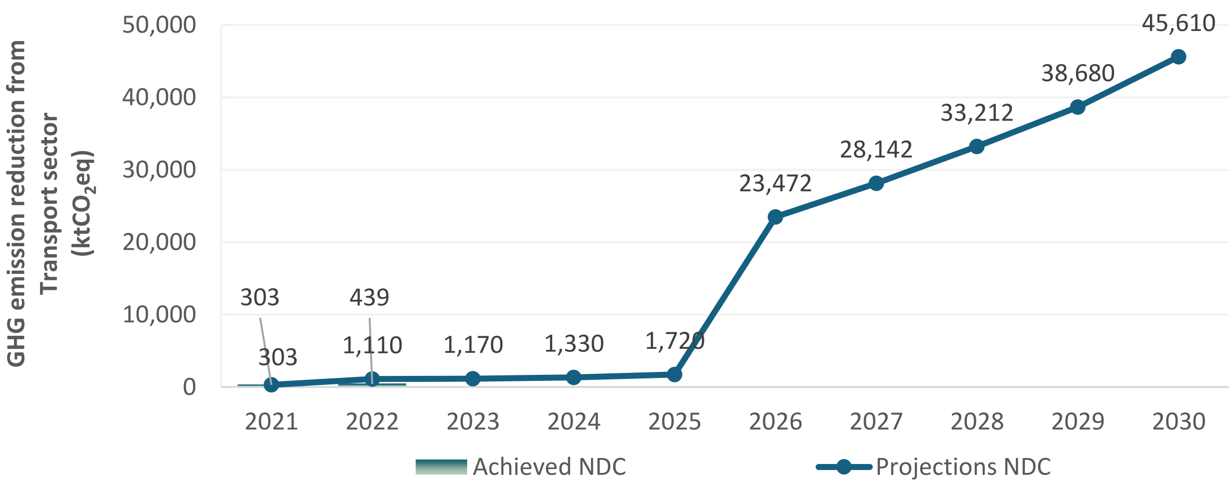


Figure 3-6: Projections of emissions reduction and achievement of NDC in the Transport sector

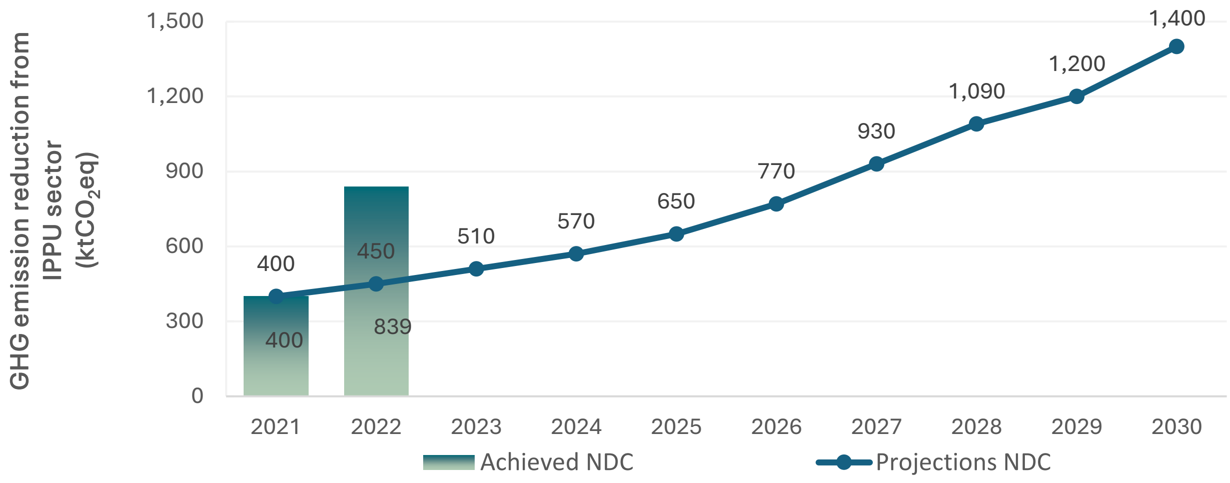


Figure 3-7: Projections of emissions reduction and achievement of NDC in the IPPU sector

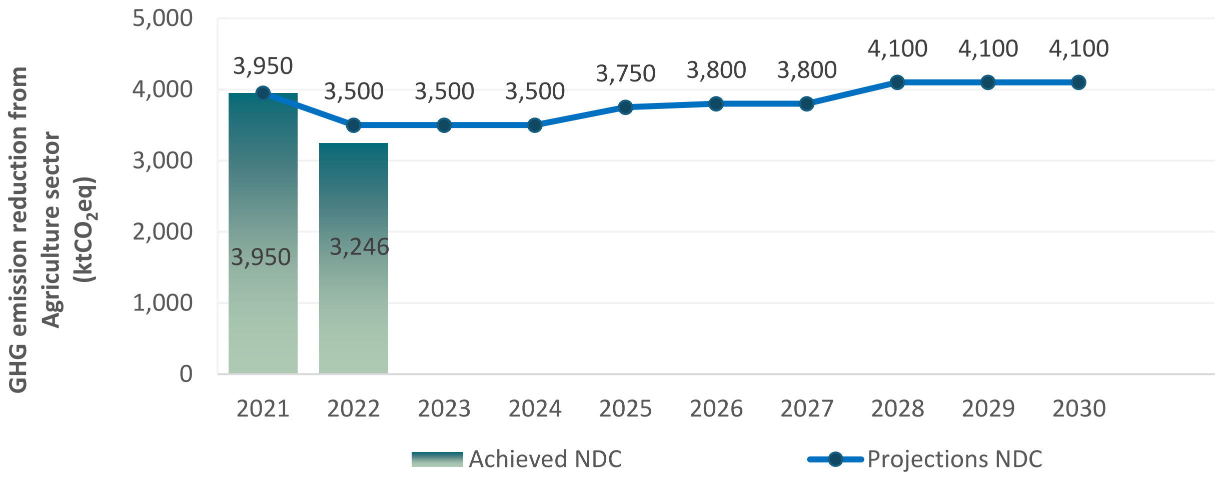


Figure 3-8: Projections of emissions reduction and achievement of NDC in the Agriculture sector

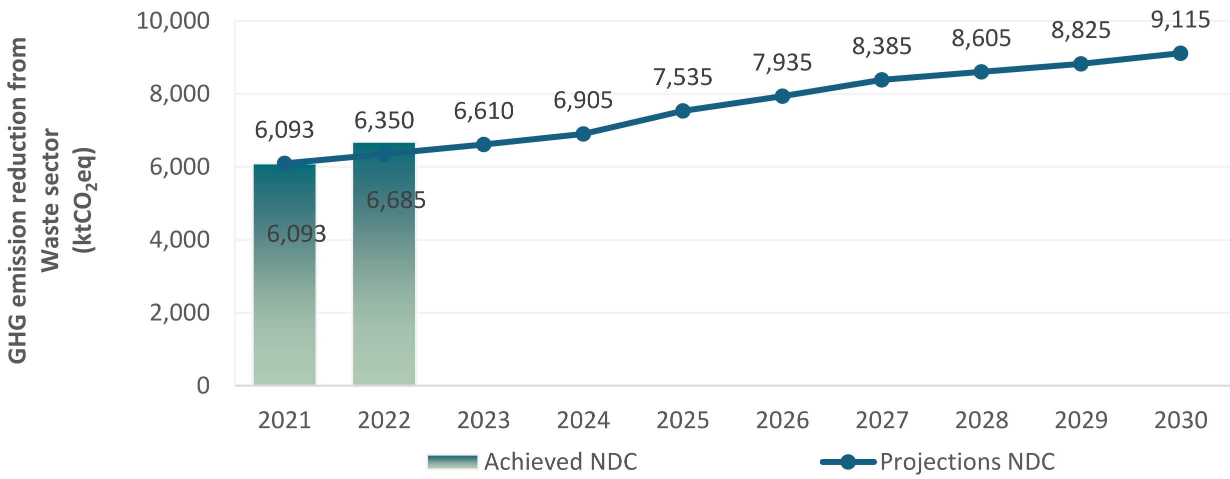


Figure 3-9: Projections of emissions reduction and achievement of NDC in the Waste sector

Table 3-2 presents information on projections of GHG emissions and removals under "without measures (WOM) scenario", "with measures (WEM) scenario" and "with additional measures (WAM) scenario". Table 3-3 presents projection of key indicators in 2030 to track progress of unconditional NDCs.

Table 3-2: Information on projections of GHG emissions and removals under "without measure scenario", "with measure scenario" and "with additional measure scenario"

Sector	Most recent year in the Party's national inventory report ($ktCO_2eq$)	Projection of GHG emissions and removals ($ktCO_2eq$)		
	2022	2030 WOM scenario	2030 WEM scenario	2030 WAM scenario
Energy	177,285.89	277,402.41	232,291.89	190,162.83
Transport	77,021.32	148,597.59	51,852.42	38,481.48
IPPU	40,527.22	32,360.00	31,898.69	31,898.69
Agriculture	68,933.74	76,630.00	55,067.00	55,067.00
LULUCF	-107,901.43	-	-110,000.00	-110,000.00
Waste	22,172.97	20,010.00	17,390.00	17,390.00
Other (specify)	-	-	-	-
Total with LULUCF	278,039.71	555,000.00	278,500.00	223,000.00
Total without LULUCF	385,941.14	555,000.00	388,500.00	333,000.00

Table 3-3: Projection of key indicators for WOM WEM and WAM in 2030

Key indicator(s):[c]	Unit, as applicable	Most recent year in the Party's national inventory report, or the most recent year for which data is available	Projections of key indicators
		2022	2030
Economy wide GHG emissions			
WOM scenario	$ktCO_2eq$	385,941.14	555,000.00
WEM scenario	$ktCO_2eq$	385,941.14	388,500.00
WAM scenario	$ktCO_2eq$	385,941.14	333,000.00

3.2.2 Methodologies and Accounting Approaches to Track Progress

This section provides information on methodologies and accounting approaches for tracking progress of the implemented NDC. Table 3-4 summarizes methodology and accounting approaches to track progress of the implemented NDC. The implemented NDCs in all IPCC sectors employ these methodologies. Table 3-5 provides information on the implemented NDCs for tracking progress.

Table 3-4: Summary of methodology to track progress of the implemented NDC

	Description
Target	GHG emissions reduction in 2030 according to the updated NDC 2022
Construction of baseline	Business-as-usual (BAU) and emissions baseline from 2020 to 2030
Indicators of unconditional NDCs	• Percent reduction relative to the BAU, Figure 3-2 • tCO_2eq reduction relative to the BAU, Figure 3-3

Table 3-5: Information on the implemented NDCs for tracking progress

	Description
Key parameters	Socio-economic parameters are obtained from NESDB and BOT.
Assumptions	Business-as-usual (BAU) without measures
Base year	2015 without measures
Starting year	2020
End year	2030
Targets	222,300 ktCO_2eq or 40% reduction from emissions sources compared to BAU 2030
Emissions in the target year 2030	388,500 ktCO_2eq
Emissions in most recent year	385,941.14 ktCO_2eq in 2022
IPCC Guidelines	All sectors in 2006 IPCC Guidelines
Metrics	100-year global warming potential from IPCC fifth assessment report (AR5)
Emissions and removals from LULUCF	Not Applicable
Mitigation co-benefits of adaptation	Not Applicable
ITMOs	1.916 ktCO_2eq in 2022

3.2.3 Summary of Information on Tracking Progress of Implemented NDC

The following tables summarize the tracking progress of the implementation and achievement of Thailand's NDC.

Table 3-6: Tracking progress made in implementing and achieving the NDC under Article 4 of the Paris Agreement

	Unit, as applicable	Reference point(s), level(s), baseline(s), base year(s) or starting point(s) {MPGs, p.67,77(a)(i)}	Implementation period of the NDC covering information for previous reporting years and the most recent year, including the end year or end of period {MPGs, p. 68, 77(a) (ii-iii)}		Target level	Target year or period	Progress made towards the NDC, as determined by comparing the most recent information for each selected indicator, including for the end year or end of period, with the reference point(s), level(s), baseline(s), base year(s) or starting point(s) (paras. 69-70 of the MPGs)
			2021	2022			
Indicator(s) selected to track progress towards the implementation and/or achievement of the NDC under Article 4 of the Paris Agreement: {MPGs, p. 65,77(a)}							
Total greenhouse gas emission	$ktCO_2eq$	555,000.00	367,668.76	385,941.14	388,500.00	2030	30.46% below the reference level
Where applicable, total GHG emissions and removals consistent with the coverage of the NDC {MPGs,p. 77(b)}	$ktCO_2eq$	555,000.00	367,668.76	385,941.14			
Contribution from the LULUCF sector for each year of the target period or target year, if not included in the inventory time series of total net GHG emissions and removals, as applicable {MPGs, p. 77(c)}	$ktCO_2eq$		-98,028.87	-107,901.43			

Energy Sector

Table 3-7: Mitigation policies and measures, actions and plans in energy sector related to implementing and achieving an NDC under Article 4 of the Paris Agreement

No	Name	Description	Objectives	Type of instrument	Status	Sector(s) affected (	Gases affected	Start year of implementation	Implementing entity or entities	Estimates of GHG emission reductions ($ktCO_2eq$)	
										Achieved	Expected
1.1	Energy efficiency improvement in designated buildings and industries	Energy savings from electricity and heat used in the designated buildings and industries	To reduce electricity consumption and improve efficiency of heat used in designated buildings and industries	Regulatory, Energy efficiency law	Implemented	Buildings, Industries, Power	CO_2	2021	DEDE, MOE	2,139.9 by 2022	5,860.0 by 2030
1.2	Building Energy Codes	Enforcement of new buildings to compile with building energy codes	Enforcement of new buildings to compile with building energy codes	Regulatory, Building Energy Codes	Planned	Buildings	CO_2	2026	DEDE, MOE	-	660.0 by 2030
1.3	Energy Saving Label	Energy saving labelling on energy consuming devices for energy efficiency	Energy efficiency	Voluntary	Implemented	Energy	CO_2	2021	DEDE, MOE	1,361.5 by 2022	9,630.0 by 2030
1.4	Energy Efficiency Resources Standards (EERS)	EERS establishes specific, long-term targets for energy savings that utilities or non-utility program administrators must meet through customer energy efficiency programs	Enforcement of energy efficiency actions on producers and consumers	Regulatory	Planned	Energy, Manufacturing Transport	CO_2	2027	DEDE, MOE	-	201.0 by 2030

Remarks: MOE represents the Ministry of Energy.
EGAT represents the Electricity Generating Authority of Thailand.
PTTEP represents the PTT Exploration and Production Plc.

Table 3-7: Mitigation policies and measures, actions and plans in energy sector related to implementing and achieving an NDC under Article 4 of the Paris Agreement (Cont'd)

No	Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation	Implementing entity or entities	Estimates of GHG emission reductions ($ktCO_2eq$)	
										Achieved	Expected
1.5	Energy Conservation Fund	The fund is to provide financial support to implementation of the energy saving to designated factories and buildings	Financial support to implementation of energy saving	Economic instrument	Planned	Energy, Manufacturing	CO_2	2026	DEDE, MOE	-	9,050.0 by 2030
1.6	Energy efficiency in power generation	Improving energy use in power plants	To reduce energy input and to produce more electricity	Voluntary	Implemented	Power	CO_2	2021	EGAT	4,219.4	8,000.0 by 2030
1.7	Wind power replacing grid electricity	Wind power replacing grid electricity	RE	Economic instrument	Implemented	Power	CO_2	2021	EGAT	1,548.5	1,110.0 by 2030
1.8	Solar Energy	Solar power replacing grid electricity and solar thermal replacing fossil fuels	RE	Economic instrument	Implemented	Power and Manufacturing	CO_2	2021	DEDE, EGAT	2,664.1 by 2022	4,930.0 by 2030
1.9	Hydro Power	Hydroelectricity replacing grid electricity	Renewable electricity	Economic instrument	Implemented	Power	CO_2	2021	EGAT	3,289.8 by 2022	3,190.0 by 2030
1.10	Biomass Energy	Biomass electricity replacing grid electricity and biomass thermal replacing fossil fuels	RE	Economic instrument	Implemented	Power and Manufacturing	CO_2	2021	DEDE, EGAT	28,043.8 by 2022	64,940.0 by 2030
1.11	Biogas Energy	Biogas electricity replacing grid electricity and biogas thermal replacing fossil fuels	RE	Economic instrument	Implemented	Power and Manufacturing	CO_2	2021	DEDE, EGAT	3,086.2 by2022	3,790.0 by 2030

Table 3-7: Mitigation policies and measures, actions and plans in energy sector related to implementing and achieving an NDC under Article 4 of the Paris Agreement (Cont'd)

No	Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation	Implementing entity or entities	Estimates of GHG emission reductions ($ktCO_2eq$)	
										Achieved	Expected
1.12	Waste to energy (MSW)	MSW electricity replacing grid electricity and MSW thermal replacing fossil fuels	RE	Economic instrument	Implemented	Power and Manufacturing	CO_2	2021	DEDE, EGAT	1,850.5 by 2022	1,630.0 by 2030
1.13	Ethanol in ICE	Ethanol blended with gasoline used in internal combustion engine (ICE)	Biofuel replacing gasoline	Regulatory	Implemented	Transport	CO_2	2021	DEDE, MOE	2,059.7 by 2022	3,740.0 by 2030
1.14	Biodiesel in ICE	Biofuels blended with diesel used in ICE	Biofuel replacing diesel	Regulatory	Implemented	Transport	CO_2	2021	DEDE, MOE	3,726.9 by 2022	4,790.0 by 2030
1.15	Geothermal electricity	Geothermal electricity replacing grid electricity	Renewable electricity	Regulatory	Implemented	Transport	CO_2	2021	EGAT	0.7 by 2022	2,076.0 by 2030
1.16	Carbon Capture and Storage (CCS) Project at Arthit Field	CCS Project at Arthit Field	CCS	Regulatory	Implemented	Transport	CO_2	2027	PTTEP	-	1,000.0 by 2030

Transport Sector

Table 3-8: Mitigation policies and measures, actions and plans in transport sector related to implementing and achieving an NDC under Article 4 of the Paris Agreement

No	Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation	Implementing entity or entities	Estimates of GHG emission reductions ($ktCO_2eq$)	
										Achieved	Expected
1.1	Improving public transportation infrastructure	Public transport infrastructure increases accessibility, efficiency, safety in transportation and quality of life	To improve urban mobility for sustainable development	Regulatory	Implemented	Improving Urban mobility	CO_2	2021	SRT	279.9 by 2022	1,780.0 by 2030
1.2	Development of rail transportation infrastructure	Rail transport network supports economic growth, connectivity, capacity of mobility, and safety in transportation	To improve inter-urban transport for sustainable development	Regulatory	Implemented	Improving inter-urban transport and green logistics	CO_2	2021	SRT, MRTA	158.7 by 2022	1,590.0 by 2030

Remarks: SRT represents the State Railway of Thailand.

MRTA represents the Mass Rapid Transit Authority of Thailand.

Industrial Process and Product Use

Table 3-9: Mitigation policies and measures, actions and plans in IPPU sector related to implementing and achieving an NDC under Article 4 of the Paris Agreement

No	Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation	Implementing entity or entities	Estimates of GHG emission reductions ($ktCO_2eq$)	
										Achieved	Expected
1.1	The use of substitute materials to replace clinker in cement production	Use of substitute materials to replace clinker in cement production	To reduce CO_2 from cement production	Economic Instrument	Implemented	Cement, Buildings and Infrastructure	CO_2	2021	DIW	371.6 by 2022	900.0 by 2030
1.2	The use of alternative materials to replace cement in ready-mixed concrete	Use of substitute materials to replace cement in ready-mixed concrete	To reduce the use of cement	Economic Instrument	Implemented	Cement, Buildings and Infrastructure	CO_2	2021	DIW	466.9 by 2022	100.0 by 2030
1.3	RAC NAMA (Refrigeration and Air Conditioning Nationally Appropriate Mitigation Actions) project	Modifying refrigeration systems under the RAC NAMA project	Replacing F-gases in Refrigeration and Air-condition	Economic Instrument	Planned	Cooling/ Heating system in Buildings, Industries and Transport	HFCs	2022	DIW	-	300.0 by 2030
1.4	Disposal and destruction of unused refrigerants	Proper disposal of refrigerants and the management of refrigeration systems in accordance with regulations	-	-	Planned	Replacing/ changing refrigerant	HFCs	2026	DIW	-	100.0 by 2030

Remarks: DIW represents the Department of Industrial Works.

Agriculture Sector

Table 3-10: Mitigation policies and measures, actions and plans in agricultural sector related to implementing and achieving an NDC under Article 4 of the Paris Agreement

No	Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation	Implementing entity or entities	Estimates of GHG emission reductions ($ktCO_2eq$)	
										Achieved	Expected
1.1	Waste management in the livestock sector	Waste management in the livestock sector	To reduce CO_2 and CH_4	Voluntary	Implemented	livestock	CO_2, CH_4	2021	DLD	3,245.9 by 2022	3,000.0 by 2030
1.2	Reduce the use of chemical fertilizers	Reduce the use of chemical fertilizers	To reduce the use of chemical fertilizers	Voluntary	Planed	Agricultural	CH_4	2026	LDD	-	100.0 by 2030
1.3	Measures for alternate wet and dry rice cultivation	Good practice in rice cultivation by alternate wet and dray	To reduce CH_4 from rice cultivation	Voluntary	Planed	Agricultural	CH_4	2023	Rice, RID	-	1,000.0 by 2030

Remarks: DLD represents the Department of Livestock Development.

LDD represents the Land Development Department.

RID represents the Royal Irrigation Department.

Rice represents the Rice Department.

Waste Sector

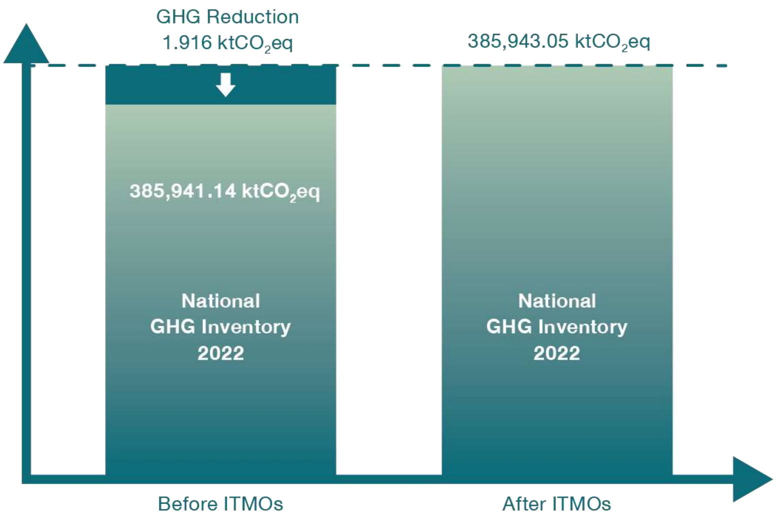
Table 3-11: Mitigation policies and measures, actions and plans in waste sector related to implementing and achieving an NDC under Article 4 of the Paris Agreement

No	Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation	Implementing entity or entities	Estimates of GHG emission reductions ($ktCO_2eq$)	
										Achieved	Expected
1.1	Burning landfill gas or using it for electricity generation	Burning landfill gas or using it for electricity generation	To reduce CH_4 from landfill gas	Regulatory	Implemented	Waste	CH_4	2021	Bangkok, LAO, Private sector	955.9 by 2022	1,860.0 by 2030
1.2	Waste to energy for electricity generation	Solid waste to energy in incinerator for electricity generation	To reduce CO_2 and CH_4 from solid waste	Regulatory	Implemented	Waste	CO_2, CH_4	2021	DLA, DEDE, LAO, Private sector	884.9 by 202	213.0 by 2030
1.3	Semi aerobic landfill	Semi aerobic landfill to reduce CH_4	To reduce CH_4 from landfill gas	Regulatory	Implemented	Waste	CH_4	2021	LAO	0.129 by 2022	0.100 by 2030
1.4	Composting and bio-extract	Composting and bio-extract	To reduce CH_4 from waste	Regulatory	Implemented	Waste	CH_4	2021	DLA, Bangkok, LAO, Private sector	303.5 by 2022	440.0 by 2030
1.5	Anaerobic digestion	A series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen	To reduce CH_4 from waste	Regulatory	Implemented	Waste	CH_4	2021	DLA, Bangkok, LAO, Private sector	14.9 by 2022	10.0 by 2030
1.6	Mechanical biological treatment	A type of waste processing facility that combines a sorting facility with a form of biological treatment such as composting or anaerobic digestion	To reduce CH_4 from waste	Regulatory	Implemented	Waste	CH_4	2021	Bangkok, LAO, Private sector	623.1 by 2022	670.0 by 2030
1.7	Waste water treatment of community	Increase wastewater into the wastewater treatment of community	To reduce CH_4	Regulatory	Implemented	Waste	CH_4	2022	LAO, WMA, Bangkok	9.5 by 2022	5.0 by 2030
1.8	Biogas from industrial wastewater and use of methane	Increasing the production of biogas from industrial wastewater and reuse the methane gas	To reduce CH_4	Regulatory	Implemented	Waste	CH_4	2021	DIW, DEDE	3,893.4 by 2021	4,000.0 by 2030

Remarks: LAO represents the Local Administrative Organization.
DLA represents the Department of Local Administration.
WMA represents the Wastewater Management Authority.

3.3 INTENTION TO USE COOPERATIVE APPROACHES THAT INVOLVE THE USE OF INTERNATIONALLY TRANSFERRED MITIGATION OUTCOMES UNDER ARTICLE 6 TOWARDS NDCS UNDER ARTICLE 4 OF THE PARIS AGREEMENT

The Kingdom of Thailand has made significant progress in implementing cooperative approaches under Article 6.2 of the Paris Agreement through two key agreements: the Implementation Agreement between the Kingdom of Thailand and the Swiss Confederation and the Implementation Agreement between the Kingdom of Thailand and Japan under the Joint Crediting Mechanism (JCM). Under the agreement with the Swiss Confederation, the Kingdom of Thailand authorized a pilot mitigation activity "the Bangkok e-bus program" as part of its cooperative approach, which has an agreement to transfer carbon credits of 500,000 tons of carbon dioxide equivalent (tCO_2eq) within the time frame from 1 October 2022 to 31 December 2030. This initiative is detailed in Thailand's Initial Report, which has been published on the UNFCCC Centralized Accounting and Reporting Platform (CARP). The first transfer of International Transferred Mitigation Outcome (ITMOs) under this program, amounting to 1,916 tCO_2eq during the crediting period from 1 October to 31 December 2022, was formally recognized by the Swiss Confederation on December 20, 2023 (Table 3-12). Meanwhile, under the JCM agreement with Japan, the Kingdom of Thailand and Japan are actively reviewing potential mitigation activities for joint authorization, further expanding their collaborative efforts to reduce greenhouse gas emissions utilizing cooperative approaches. Table 3-13 and Figure 3-10 show the impact of ITMOs on Thailand's National GHG inventory in the transferred year.



Note: Graphics scale of GHG reduction is not to scale

Figure 3-10: Illustration of adjustment of Thailand's National GHG Inventory after ITMOs

Table 3-12: Tracking progress made in implementing and achieving the NDC under Article 4 of the Paris Agreement

	Unit, as applicable	Reference point(s), Level(s), Baseline(s), base Year(s) or starting Point(s){MPGs, p. 67,77(a)(i)}	Implementation period of the NDC covering information for previous reporting years and the most recent year, including the end year or end of period {MPGs, p. 68, 77 (a)(ii-iii)}									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Annual quantity of ITMOs first transferred (para. 23(c), annex to decision -/CMA.3) (para. 77 (d)(ii) of the MPGs)	$ktCO_2eq$		0	1.916								
Annual quantity of mitigation outcomes authorized for use for other international mitigation purposes and entities authorized to use such mitigation outcomes, as appropriate (para 23(d), annex to decision -/CMA.3) (para.77(d)(ii) of the MPGs)	$ktCO_2eq$		0	1.916								
Annual quantity of ITMOs used towards achievement of the NDC (para. 23(e), annex to decision -/CMA.3) (para.77 (d)(ii) of the MPGs)	$ktCO_2eq$		0	0								
Net annual quantity of ITMOs resulting from paras. 23(c)-(e), annex to decision -/CMA.3 (para. 23(f), annex to decision - /CMA.3)	$ktCO_2eq$		0	1.916								

Table 3-13: Impacts of ITMOs on National GHG Inventory of Thailand

Emissions in year	GHG Inventory before ITMOs, $ktCO_2eq$	ITMOs, $ktCO_2eq$	GHG Inventory after ITMOs, $ktCO_2eq$	Change, %
2022	385,941.14	1.916	385,943.06	0.0005

Chapter IV

INFORMATION ON CLIMATE CHANGE IMPACTS AND ADAPTATION

THAILAND'S FIRST BIENNIAL TRANSPARENCY REPORT

CHAPTER 4
INFORMATION ON CLIMATE CHANGE IMPACTS AND ADAPTATION

Thailand is highly vulnerable to climate change. According to the Global Climate Risk Index 2021, it was ranked 9th among countries most affected by the impacts of climate change from 2000 to 2019 (Eckstein et al., 2021). The effects of climate change are reflected across the country's different dimensions of national circumstances.

Thailand is characterized by diverse geomorphology such as mountains, plains, and coastal areas. The mountainous region in the north is heavily prone to flash floods and landslides, particularly during the monsoon season. Provinces in coastal areas face the risks of increased flooding and coastal erosion because of sea level rise. The Gulf of Thailand increased at a rate of 3.23 to 19.19 mm/year, depending on the location of the tide gauge station (Pongsiri et al., 2020; Taninpong et al., 2021). The consequential flooding from rising sea levels will also spillover in the low-lying urban and rural areas of the country.

In the socio-economic context, two key issues characterize Thailand's vulnerability to climate change. The first is related to the rapid urbanization of its key economic cities like Bangkok. The capital generates 47% of the country's Gross Domestic Product (GDP) (Office of the National Economic and Social Development Council, 2024b). Consequently, it has a high population density compared to other regions because of the economic opportunities that it provides. In 2023, 53.6% of the population lived in urban areas (United Nations, 2024c). Thailand's urbanization rate is expected to reach 64.4% by 2040 and 69.5% by 2050 (United Nations, 2018). The rapid urbanization of Bangkok leads to land subsidence which increases the city's vulnerability to flooding and potential sinking. The second issue is that Thailand is transitioning to an aging society. The country's median age in 2021 was 39 years while that of the Southeast Asian region is 30 (United Nations, 2024a). Thailand is projected to be a super-aged society with the proportion of the population aged 60 and above reaching about 36% by 2050 (United Nations, 2024b). The rapid aging of Thai society will impact not just Thailand's economic productivity but also its capacity to adapt to climate change.

The economic impact of climate change on Thailand is reflected in its three key sectors: agriculture, manufacturing, and services. In 2023, these sectors make up 8.6 %, 24.9 %, and 61.0 % of the Thai economy, respectively (Office of the National Economic and Social Development Council, 2024a). The agricultural sector is vulnerable to climate change because various extreme weather events, such as drought, higher temperatures and increased rainfall intensity, can reduce the sector's harvest and output (Jatuporn & Takeuchi, 2023; Pak-Uthai & Faysse, 2018). The manufacturing sector, characterized by fixed assets, is highly susceptible to flood risk. The occurrence of the 2011 flood in Thailand underscores this risk. It is estimated that the economic damage and losses that the manufacturing sector incurred from the 2011 flood amounted to USD 27 billion (Haraguchi & Lall, 2015). Thailand's tourism industry falls under the services sector. Tourism accounted for about 7% of the economy in 2022 (Ministry of Tourism & Sports, 2024). The changing climatic patterns can negatively affect the interest that the country draws from foreign tourists and reduce the demand for domestic travel.

4.1 OBSERVED AND POTENTIAL IMPACTS BY SECTOR

Climate change impacts Thailand's economy, ecosystems, sectors, health, and livelihoods unevenly, with varying effects across different sectors and regions. Thailand's NAP identifies six priority sectors: water resources management, agriculture and food security, tourism, public health, natural resources management, and human settlements and security. See the details of risk areas under RCP4.5 and RCP8.5 scenarios in the NAP (Department of Climate Change and Environment, 2023) https://unfccc.int/sites/default/files/resource/NAP_THAILAND_2024.pdf.

4.1.1 Water Resources Management Sector

Climate change is impacting Thailand's water resources management by creating variability in water availability. Currently, the sector manages 285,221 million m^3 of surface water, with agriculture accounting for 83% of the total demand. Future projections under RCP4.5 and RCP8.5 scenarios show decreased rainfall, but uneven distribution. This means some areas may face severe droughts while others experience severe floods.

4.1.2 Agriculture and Food Security Sector

Climate change affects Thailand's agriculture and food security through changes in temperature, rainfall, sea levels, and seasons. These changes impact soil and water resources, plant diseases, and pest habitats, indirectly reducing agricultural productivity. In recent years, storms, droughts, and floods have damaged thousands of square kilometers of agricultural land, causing significant financial losses. Storms affected 1,178.91 km^2 in 2022, droughts affected 2,848 km^2 in 2020, and floods affected 9,120 km^2 in 2021. Future projections show that 25,569.25 km^2 of rice fields in the Central Plain and other crops in the northern regions are at high risk of flooding and drought under RCP4.5 and RCP8.5 scenarios. National climate models identify several vulnerable provinces, highlighting the need for strong adaptation strategies to protect food security.

4.1.3 Tourism Sector

Climate change impacts Thailand's tourism because the sector relies on specific climatic conditions for nature-based, historical, and cultural tourism. Shorter, milder winters and longer, hotter summers with more frequent heavy rains can damage fragile ecosystems and cultural sites. This makes tourist destinations less attractive. Changes in temperature and humidity affect plant species and seasonal blooms. Altered rainfall patterns impact water volumes at natural sites, limiting activities like rafting and hiking. These changes may reduce tourist satisfaction and threaten future tourism activities. This puts the 10.55% of Thailand's labor force dependent on tourism at risk. A study by Office of Natural Resources and Environmental Policy and Planning (ONEP) identified 736 tourist destinations in drought risk areas and 169 in flood risk areas, particularly in the North, Central Plain, West, South, and Northeast.

4.1.4 Public Health Sector

Climate change impacts public health in Thailand through changes in ecosystems, leading to health issues like respiratory diseases, cardiovascular diseases, heat-related illnesses, malnutrition, and mental health problems. Natural disasters such as floods, storms, and droughts, made worse by climate change, cause injuries, deaths, and disrupt public health services. Higher temperatures result in more heat-related illnesses, especially among outdoor workers. Climate change affects the spread of diseases like dengue, malaria, and diarrhea by altering environmental conditions. Respiratory diseases and malnutrition rates also change due to the climate. These health issues increase public health costs and cause economic losses. Flood-prone areas with high health risks include Bangkok, the Upper Central Plain, the Northeastern region, and the Southern region. Drought-prone areas include Bangkok, the Northern region, the Central Plain, the Western region, and most of the Northeastern region.

4.1.5 Natural Resources Management Sector

Climate change impacts Thailand's natural resources management sector in various ways. It affects the life cycles of plants and animals, including their reproduction and migration. Changes in temperature and rainfall can reduce or even cause extinction of certain species. Climate change can worsen issues like overharvesting and habitat loss. It also disrupts biogeochemical cycles, potentially increasing carbon dioxide (CO_2) levels from faster soil decomposition. This affects biodiversity, water resources, air quality, and food security. Rising temperatures between 1.0-3.5ºC over the next 100 years will change climate zones and species distribution. Species that cannot adapt may go extinct, leading to biodiversity loss and altered ecosystems.

4.1.6 Human Settlements and Security Sector

Lastly, climate change will increasingly impact human settlements and security in Thailand by causing more severe floods, rising sea levels, and intensified heat stress. Historically, settlements were designed with climatic conditions in mind, but modern development has reduced this focus. Many urban areas, especially Bangkok and its surroundings, are at high risk from climate change. Floods will increase due to changing rainfall patterns and rising sea levels, particularly in the Central Plain and coastal areas. Heat stress will intensify, especially in the Central Plains and northern regions, leading to dangerously high heat indices and worsening living conditions.

4.2 PRIORITIES AND BARRIERS

4.2.1 Domestic Adaptation Action Priorities and Progress

The United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) identifies three major adaptation priorities for Thailand, considering the climate risks that the country faces. These are strengthening its early warning system, reinforcing the resilience of its infrastructure, and improving its dryland agriculture crop production (Figure 4-1). UNESCAP estimates that Thailand's adaptation costs related to climate hazards such as floods, tropical cyclones and droughts is at USD 5 billion, or 1.2% of its GDP. This figure is based on the RCP 8.5 climate scenario.

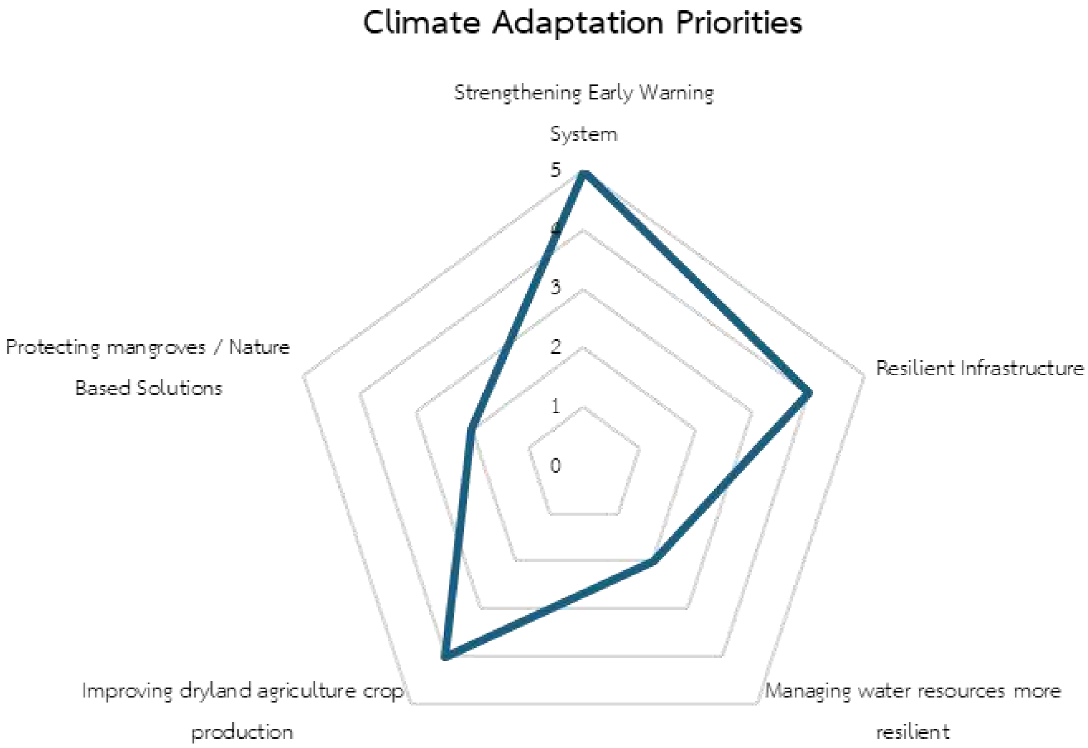


Figure 4-1: Climate adaptation priorities for Thailand from the Risk and Resilience Portal of the UNESCAP. A score of 5 denotes the highest adaptation priority for the country

Source: United Nations Economic and Social Commission for Asia and the Pacific (2024)

The Climate Change Master Plan (2015-2050) plays a crucial role in Thailand's adaptation efforts by providing a long-term policy framework aimed at creating a low carbon emission and climate-resilient society. Approved on July 14, 2016, it includes three strategies: climate adaptation, GHG mitigation, and enabling climate management. The adaptation strategy focuses on six sectors: water resources management, agriculture and food security, tourism, public health, natural resources management, and human settlements and security.

To establish a clear framework for climate change adaptation, ONEP developed the NAP, aiming to mainstream climate adaptation across sectoral and sub-national levels and guide budget allocation for related projects and programs. Approved by the NCCC on November 19, 2018, the NAP envisions a resilient Thailand with the capacity to adapt to climate change impacts, progressing towards sustainable development. Its three core missions are: integrating climate change adaptation guidelines and strategies into all sectors and levels for climate-resilient development; enhancing the capacity and awareness of development partners to effectively implement climate policies and plans; and developing databases, research, knowledge, and technology to support adaptation. The NAP's guidelines and measures provide a framework for adaptation actions, assisting relevant agencies in the six key sectors. The sectoral targets and approaches, and specific sectoral focal points for climate change adaptation under the NAP were provided (Department of Climate Change and Environment, 2023) https://unfccc.int/sites/default/files/resource/NAP_THAILAND_2024.pdf.

The NAP's implementation is designed to align with the National Strategy and the National Economic and Social Development Plan, recognizing that climate change adaptation is a long-term process. The implementation is divided into three periods: the preparation period (2018 - 2021), the implementation period (2022 - 2026), and the achieving goals period (2027 - 2037) (Office of Natural Resources and Environmental Policy and Planning, 2022). The preparation period focuses on laying the foundation and promoting policy actions. The implementation period emphasizes developing mechanisms and capacity building. The achieving goals period concentrates on taking actions to meet the outcomes and goals.

4.2.2 Adaptation gaps to adaptation Actions

Thailand faces several challenges in implementing adaptation measures at the national level, which span across multiple dimensions. Gaps can be identified as shown in Table 4-1.

Table 4-1: Thailand's gaps to adaptation actions

Topics	Gaps to adaptation actions
Development of indicators	There are no clear indicators for adaptation actions under NAP.
Uncertainty in implementing long-term plans	Climate change impacts are uncertain and take time to prove, so we need time to build climate resilience.
Knowledge and awareness	Responsible agencies still lack knowledge and awareness of climate adaptation.
Integrating adaptation issues and stakeholder engagement	Some agencies are still not fully integrating adaptation issues into their action plan, including encouragement and stakeholder engagement.
Capacity	Insufficient technical proficiency, expertise, funding, and technology and knowledge transfer to drive the implementation adaptation.

The barriers and challenges that Thailand faces in executing its adaptation measures can be categorized into two types: sector-specific challenges and cross-cutting challenges. Table 4-2 provides a summary of the barriers and challenges for each sector.

Table 4-2: The sectoral gaps to adaptation actions

Sectors	Gaps to adaptation actions
Water resources management	- **Integration and coordination Limitation**: Limited integration and coordination among government agencies involved in water resource management. - **Central Agencies**: Lack of agencies or responsible parties for defining specific terminology, roles, and operational frameworks. - **Framework:** There is still no analytical framework, reference points or basic data for climate change data analysis for adaptation. - **Cross-cutting Expert**: Lack of experts or individuals with knowledge and understanding to correctly separate issues and prioritize them to achieve measures and approaches under the NAP. - **Data Collection**: Most projects are implemented without baseline data collection prior to execution, only having the results of the implementation. This creates a gap in analyzing project outcomes. - **Financial Support**: Operational and Maintenance (O&M) budget constraints and lack of knowledge and understanding among local personnel.
Agriculture and food security	- **Knowledge Limitation**: Lack of knowledge on adaptation and lack of access to technologies that can help adapt to climate change. - **Financial Support**: Lack of access to sources of funding or financial support necessary for implementing adaptation measures. - Activities or projects related to climate change adaptation in the agriculture and food security sectors involve multiple agencies within the ministry. Therefore, collaboration from all sectors is needed to drive these activities or projects to achieve maximum efficiency and effectiveness. - **Climate Research and Study**: Government research and studies on climate change continue to face limitations in receiving research funding
Tourism	- **Knowledge Limitation**: Tourists and tourism business owners lack knowledge about the impact of climate change as well as knowledge on how to adapt to climate change. - **Communication Limitation**: There are limitations in disseminating and communicating information about the impacts of climate change to both domestic and international tourists as well as the tourism business owners. - **Financial Support**: Tourism business owners and government agencies that manage natural tourist attractions still lack access to sources of funding for adaptation activities, infrastructure preparation, and monitoring of the impacts caused by climate change. - **Mechanism Support**: There is a lack of support mechanisms, such as disaster risk insurance or funds to assist affected tourism business owners, or joint benefits that support both adaptation and greenhouse gas reduction.

Table 4-2: The sectoral gaps to adaptation actions (Cont'd)

Sectors	Gaps to adaptation actions
Public health	- **Awareness and Knowledge Limitation**: Public health personnel still lack awareness and knowledge about the relationship between climate change and public health. - **Research Limitation**: Limited research on climate-related diseases. - The supporting budget for public health operations remains limited. - **Data Limitation**: Lack of centralized databases on the impacts of climate change on human health at both national and local levels.
Natural resources management	- **Knowledge and Research Limitation**: Limited knowledge and research on the impacts of climate change on ecosystems, both on land and in coastal and marine ecosystems. - **Financial Limitation**: Local environmental agencies lack the budget, personnel and knowledge to implement adaptation measures to protect natural resources and ecosystems from the impacts of climate change. - **Data Limitation**: Natural resource management involves multiple agencies, which poses a challenge in collecting adaptation project data from all relevant agencies within each sector. - The budget allocated to government agencies for operations is insufficient.
Human settlements and security	- **Data Limitation**: Lack of local climate change data that can be used for climate change adaptation planning. - **Mechanism Limitation**: There are still no mandatory laws on buildings, structures, and climate change warning systems. - **Unclear Responsibility**: The agency or specific group responsible for overseeing climate change adaptation efforts still lacks clarity in its responsibilities and does not provide adequate support in related areas. - There is still a lack of budget to support the development of knowledge and skills of stakeholders, including equipment to assist and protect against disasters resulting from climate change.
Cross-cutting Issues	- **Knowledge Limitation**: Key personnel lack knowledge about climate change impacts and suitable adaptation measures. - **Financial Support**: Multi-year adaptation projects often suffer from inconsistent financial backing, hindering progress. - **Central Database**: Government agencies have fragmented climate change data, lacking coordination and integration. - **National Climate Information Center**: There is no centralized national center for compiling climate-related information. - **Access to Technologies**: Stakeholders do not have universal access to adaptation technologies.

Source: Adapted from Office of Natural Resources and Environmental Policy and Planning (2022)

4.3 ADAPTATION STRATEGIES, POLICIES, PLANS, GOALS AND ACTIONS TO INTEGRATE ADAPTATION INTO NATIONAL POLICIES AND STRATEGIES

Thailand plays a crucial role in achieving Global Goal on Adaptation (GGA), given its vulnerability to climate change impacts. Thailand focuses on developing a NAP tailored to its context, emphasizing inclusive participation. Efforts also include raising public awareness, enhancing early warning systems to mitigate extreme weather impacts, promoting research and technology development in areas like climate-resilient agriculture, and fostering international cooperation to strengthen implementation and financial support.

4.3.1 Water Resources Management Sector

The NAP has set climate adaptation guidelines for water resources management that follow river basin principles suitable for local areas. These guidelines are categorized into upstream management, midstream and downstream management, and downstream water management. Additionally, the NAP outlines supporting mechanisms to enhance overall water resources management. The guidelines and expected outputs for each adaptation approach in this sector are provided in the NAP (Department of Climate Change and Environment, 2023) https://unfccc.int/sites/default/files/resource/NAP_THAILAND_2024.pdf.

The water resources management sector has strategies, policies and plans that have been designed to embed climate change adaptation into it. The details are displayed below.

The 20-year Master Plan on Water Resources Management (Phase 1 Adjustment, 2023–2037), the ONWR, in collaboration with relevant agencies, has updated the 20-Year Master Plan on Water Resources Management (Phase 1 Adjustment: 2023–2040) to align with the SDGs, the 20-Year National Strategy (2018 – 2037), the Master Plan under National Strategy on Water Resources Management (Topic 19), the 13th National Economic and Social Development Plan (2023 - 2027), and other related plans. This serves as a framework for managing Thailand's water resources over the next 20 years.

The vision of this master plan is for "Thailand to achieve sustainable water resource management through the participation of all sectors, balancing dynamic development to ensure water security in all dimensions" under five development areas:

- **Consumption Management**: Aims to provide equitable water access by building, expanding, and upgrading 32,701 systems to benefit 7.2 million households, securing 174.13 million m^3 of backup water, increasing urban water production by 2.88 million m^3 per day, and standardizing village water systems at affordable prices.

- **Water Security for Production**: Targets include supplying 3,239 million m^3 to rain-fed agriculture, benefiting 915,200 ha, building reservoirs and water diversion systems of 4,505 million m^3 for 745,600 ha, repairing transferred projects, and consolidating 480,000 ha for irrigation.

- **Flood and Inundation Management**: Seeks to mitigate damages from floods and climate change by improving 1,978.14 km of waterways, protecting 380 urban areas, managing 13 flood-prone zones, supporting emergency adaptation, and upgrading dams.

- **Ecosystem Conservation and Restoration**: Focuses on restoring 220,000 ha of watershed forest, reducing soil erosion on 424,000 ha, building 759 wastewater treatment facilities, and conserving natural water bodies.

- **Management and Organizational Development**: Establishes policies, databases, legal frameworks, and community participation to strengthen water management, improve data integration, install warning systems, enhance local organization capacity, and foster community-level water management for sustainable governance.

The Water Resources Act (2018), enacted in 2019, is Thailand's first comprehensive law for integrated water resource management. It streamlines budget use, enhances coordination, and improves database clarity among government agencies for more efficient water management. Its provision on droughts and floods highlights the need to address water-related issues urgently. The Committee on River Basin is tasked with creating a plan to prevent and solve these problems, including water quality maintenance and coordination with relevant agencies for implementation. It also has a provision on protecting areas around water sources, creeks, and wetlands for public water conservation. The provision includes setting guidelines for land use to prevent harm and promote the development of these public water resources.

4.3.2 Agriculture and Food Security Sector

The NAP guidelines for agriculture and food security focus on improving crop varieties, adjusting farming practices, and enhancing livestock and fishery management. They also include supporting infrastructure improvements like expanding irrigation systems and digging wells. Please see the details in the NAP (Department of Climate Change and Environment, 2023) https://unfccc.int/sites/default/files/resource/NAP_THAILAND_2024.pdf.

The Agriculture Strategic Plan on Climate Change *(*2023 – 2027) by the Ministry of Agriculture and Cooperatives marks a significant step in integrating climate adaptation into national policies and strategies. As the first action plan to set concrete targets for GHG reduction, it reflects the agricultural sector's commitment to aligning with Thailand's NDCs. The overarching objective is to achieve carbon neutrality by 2050 and net-zero carbon emissions by 2065. One of the development issues focuses on enhancing the adaptive capacity of farmers and businesses involved in the agricultural supply chain. The goal is to boost resilience across the agricultural sector to mitigate the impacts of climate change. Key objectives include increasing the adoption of modern digital technologies among farmers, promoting sustainable practices like Alternate Wetting and Drying (AWD) for rice cultivation, and improving access to agricultural insurance and irrigation systems. Development strategies include Climate-Smart Agriculture (CSA) initiatives, the use of digital technology throughout the supply chain, and improving soil health and water access. The overall approach aims to increase productivity, reduce risks, and enhance sustainability in agriculture in the face of climate change.

4.3.3 Tourism Sector

The NAP adaptation action guidelines for the tourism sector emphasize risk management and damage mitigation from climate-related disasters, developing tourism that aligns with climate changes, and building capacity for sectors to adapt. The guidelines are categorized into managing natural tourism destinations, managing man-made tourism destinations, and supporting mechanisms for tourism (Department of Climate Change and Environment, 2023).

The tourism sector's adaptation measures to climate change include shifting from natural to man-made attractions, developing early warning systems, and creating climate-resilient infrastructure. Technical measures involve technology like storm-resistant buildings and rainwater recycling, while managerial measures focus on water conservation and seasonal site closures. Educational measures train tourists and businesses on climate adaptation, and research-based measures track coral bleaching and seawater quality. Behavioral changes are encouraged, such as sea water conservation efforts on Koh Mak Island.

Government agencies are also taking action to support adaptation in the tourism sector. The MOTS supports the shift to man-made tourist attractions. The Fine Arts Department rehabilitates historical sites damaged by natural disasters, especially floods. Future measures include promoting community-based and creative tourism to highlight local history and culture, providing a personal visitor experience, and reducing pressure on natural resources.

4.3.4 Public Health Sector

The NAP adaptation guidelines for public health focus on climate change-related health risks. These include respiratory diseases, vector-borne diseases, heat-related illnesses, and health issues from floods, droughts, and water and food scarcity. They prioritize vulnerable groups like children, the elderly, pregnant women, patients with chronic conditions, farmers, laborers, and the underprivileged. Please see the details in the NAP (Department of Climate Change and Environment, 2023) https://unfccc.int/sites/default/files/resource/NAP_THAILAND_2024.pdf.

The Health National Adaptation Plan (HNAP), first phase (2021 – 2030), offers essential guidance to foster multisectoral collaboration aimed at enhancing and developing health resilience against the impacts of climate change. Through the HNAP, Thailand aims to reduce illness, minimize health impacts, and become a leading center in Asia for managing health risks caused by climate change. Table 4-3 shows the 4 strategies under HNAP and their details.

Table 4-3: Strategies under the HNAP, first phase (2021 – 2030)

Strategy	Goals	Approach and implementation
Strengthening communities and their skills in adaptation and health literacy to cope with health risks from climate change.	- The citizens have health literacy and skills to take care of themselves and their community. - Vulnerable groups receive climate-related health protection and are able to adapt promptly.	- To develop know-how and participation from the community in climate-related health prevention and treatment. - To enhance the primary health care system in order to develop skills, increase participation, and improve the quality for of the people in the community

Table 4.3: Strategies under the HNAP, first phase (2021 – 2030) (Cont'd)

Strategy	Goals	Approach and implementation
Integrating the resources of all sectors to proficiently drive public health implementation climate change.	- Public health management at all levels is effective and efficient in response to climate change.	- To coordinate with all sectors across the country to drive public health implementation for climate change. - To integrate resources within public health sector and other sectors to drive public health policies. - To strengthen Thailand as a center for climate-related health risk management in ASEAN.
Strengthening public health preparedness for climate change to support economic and social development and security.	- The risk areas are equipped with public health management for climate change on an international standard.	- To increase management efficiency and capacity of the public health system to support the risk areas from climate change. - To support climate change-related public health management according to sustainable development framework.
Developing the national public health system in response to climate change on an international standard.	- Public health facilities are efficiently developed. - Innovations for climate change-related public health management are available. - The costs of climate change-related health issues decrease.	- To build leadership, good governance, and fiscal system to respond to climate change. - To build mechanisms and develop public health laws and regulations to manage climate change-related health risks. - To develop information technology and health surveillance system to monitor and assess health impacts. - To develop medical technologies and innovations for patients with climate change-related diseases.

Source: Adapted from Department of Health (2021)

4.3.5 Natural Resources Management Sector

The NAP guidelines for natural resources management are divided by ecosystem type. They include terrestrial, wetland, and marine and coastal ecosystem management. Additionally, there are supporting mechanisms for managing natural resources and biodiversity. Please see the details in the NAP (Department of Climate Change and Environment, 2023) https://unfccc.int/sites/default/files/resource/NAP_THAILAND_2024.pdf.

Thailand's adaptation measures in the natural resources management sector focus on conservation, restoration, and sustainable utilization. These efforts are led by the MNRE, including the Department of National Parks, Wildlife and Plant Conservation (DNP) for forests and mangroves in protected areas and national forest reserves, the Department of Marine and Coastal Resources (DMCR) for marine areas, and the ONEP for integrating climate adaptation into biodiversity planning.

National Biodiversity Action Plans 2023 – 2027 - The ONEP, in collaboration with the United Nations Development Programme (UNDP), Thailand, is implementing the Global Biodiversity Framework Early Action Support (GBF-EAS) project under the Kunming-Montreal Global Biodiversity Framework. This project involves drafting the NBSAPs (2023-2027). The plan integrates climate change adaptation issues into **Goal 4**, which focuses on reducing threats to biodiversity from climate change and pollution. It also aims to increase urban green spaces to restore and maintain ecosystem services. Furthermore, the plan incorporates nature-based and/or ecosystem-based adaptation approaches to mitigate the impacts of climate change and apply them across various sectors.

Regulation of the Prime Minister's Office on the Conservation and Utilization of Biodiversity (2020) - Thailand has established the National Committee on the Conservation and Utilization of Biodiversity (NCB), chaired by the MNRE. Its primary responsibilities include proposing biodiversity policies, strategies, and management plans to the Cabinet, overseeing their implementation, and ensuring compliance with international biodiversity agreements. The committee also provides advice to the Cabinet and coordinates with government agencies to promote sustainable biodiversity use and conservation across the country. The ONEP is responsible for providing information on biodiversity, developing policies and strategies, and supporting collaboration between public and private sectors. It also handles international negotiations on access to biological resources, ensures fair benefit-sharing, and coordinates with state agencies to implement biodiversity management plans. The office also monitors, evaluates, and reports on national biodiversity efforts.

Moreover, Thailand also has various laws related to natural resource management that indirectly contribute to climate adaptation by promoting conservation, ecosystem preservation, and sustainable resource use and achieving the goals of the National Adaptation Plan for climate change such as the following:

National Park Act 2019: Protects national parks, promoting biodiversity conservation.

Wildlife Preservation and Protection Act 2019: Protects endangered species and their habitats.

Community Forest Act 2019: Encourages local communities to manage forests.

Fisheries Act 2015: Regulates sustainable fishing practices.

Marine and Coastal Resources Management Act B.E. 2015: Ensures the protection of marine ecosystems.

4.3.6 Human Settlement and Security Sector

The NAP adaptation guidelines for human settlements and security aim to reduce risks and damages from climate-related disasters. They focus on strengthening the preparedness and adaptive capacity of individuals, communities, and cities. Please see the details in the NAP

(Department of Climate Change and Environment, 2023) https://unfccc.int/sites/default/files/resource/NAP_THAILAND_2024.pdf.

The National Disaster Prevention and Mitigation Plan (2021-2030) was developed under the concept of "Resilience by Smart DRM for 3s" with the goal of reducing existing risks, preventing new risks, and applying research, innovation, technology, and wisdom to enhance the capacity of all sectors in disaster risk management. The plan is driven by five key strategies:

1) Risk Reduction

- Focuses on managing potential risks by reducing vulnerabilities and increasing preparedness for disasters.

2) Management and Innovation

- Enhances disaster management systems by incorporating research, innovation, technology, and wisdom to improve disaster prevention and risk management capabilities.

3) International Partnerships

- Promotes sustainable disaster risk management partnerships at national and international levels, encouraging all sectors to participate and elevate standards.

4) Integrated Emergency Management

- Establishes guidelines for emergency management organizations and procedures to support operations during emergencies.

5) Sustainable Recovery

Ensures that communities and society can recover sustainably after an emergency through effective post-disaster recovery operations.

Climate change adaptation in the human settlement and security sector occurs at three main levels: individual/household, community, and city-wide.

1) Individual/household level

Individual or household adaptation actions include raising house floors, building flood prevention walls, and having a second home. These actions depend on personal awareness and circumstances.

2) Community level

Community-level climate change adaptation includes building walkways along riverbanks and planning community areas to address climate impacts. This requires support mechanisms like financing systems. Thailand has funds for climate adaptation, such as post-disaster renovation loans and the Stable Home Project, which provides funding for home improvements and infrastructure development to reduce disaster impacts.

3) City level

As urbanization increases, cities are adapting to climate change by creating public spaces, green areas, and infrastructure systems like dams and drainage systems.

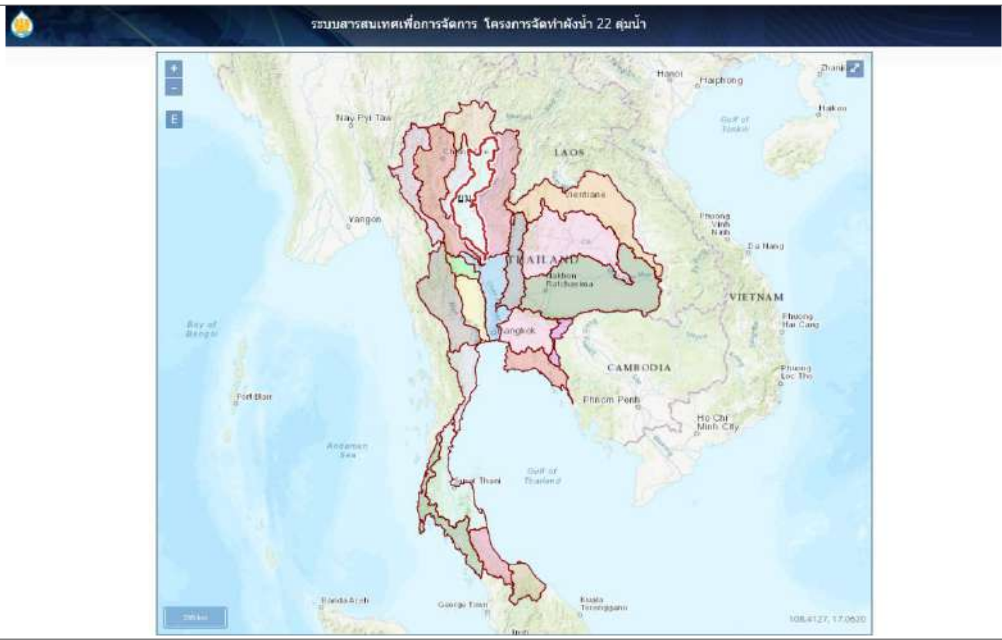
4.4 PROGRESS ON IMPLEMENTATION OF ADAPTATION

4.4.1 Water Resources Management Sector

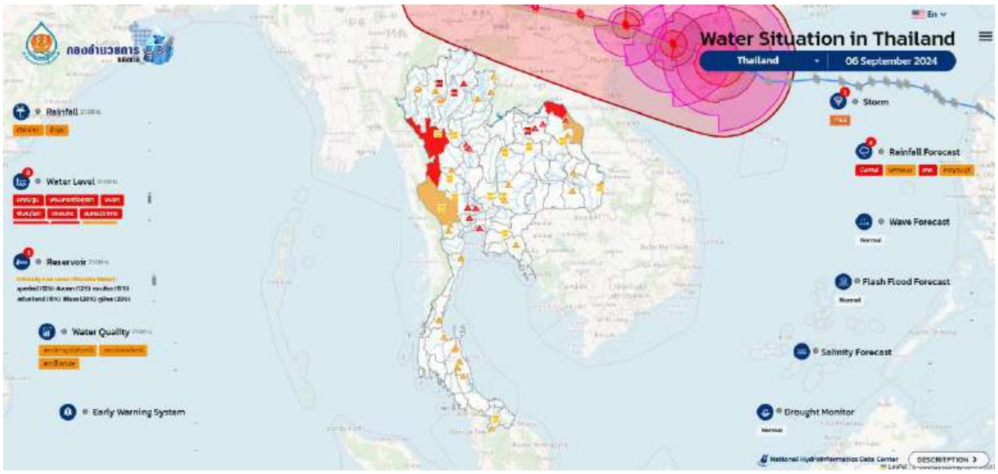
Table 4-4: Progress on implementation of adaptation under water resources management sector

Approach 1: Upstream management	
Measure	(3) Promote economic instruments as incentives for upstream communities to protect and conserve the ecosystem.
Responsible agencies	MNRE, and DNP
Progress related to Measure	Thailand has adopted the Payment for Ecosystem Services (PES) principle to assign economic value to the country's natural resources. This initiative benefits communities responsible for conserving protected areas, such as national parks and wildlife sanctuaries. Pilot PES projects include areas such as 1. Doi Inthanon National Park (watershed forest ecosystem) 2. Tarutao National Park (Marine ecosystem and coastal resources) 3. Doi Chiang Dao Biosphere Reserve (watershed forest ecosystem) 4. Khlong Lan National Park (recreation) 5. Huai Kha Khaeng Wildlife Sanctuary (biological diversity) 6. Khao Chamao-Khao Wong National Park (water source for industry)
Approach 2-1: Midstream and downstream management (Flood management)	
Measure	(1) Develop infrastructure for flood responses, which would consider the characteristics of each locality, ecosystem, and community.
Responsible agencies	MOAC, MNRE, MOI, Ministry of Digital Economy and Society (MDES), MHESI, ONWR, Ministry of Energy, Ministry of transport, Ministry of Industry (MIND), Royal Initiative Discovery Foundation, Office of the National Broadcasting and Telecommunication Commission (NBTC), and The Public Relations Department (PRD)
Progress related to Measure	Measures for handling the rainy season. It is crucial that steps be taken promptly to handle the challenge of controlling the rainy season to prevent or mitigate the effects of flooding that may irritate the public. In 2023, 12 measures were identified. 1. **Forecast and Identify Areas Prone to Flooding and Damage:** Forecast potential flood-prone areas and places likely to experience damage during the rainy season (March and onward). 2. **Low-Lying Area Management:** Manage low-lying areas to support flood mitigation (within August). 3. **Revise and Improve Water Management Plans:** Adjust water management plans to ensure efficient usage and prepare for possible shortages (starting from the rainy season through the dry season).

	4. **Prepare for Repairs and Renovations:** Prepare for repairs and improvements to infrastructure, water systems, and water management projects to ensure usability and resilience during the rainy season (before and throughout the rainy season). 5. **Prepare Equipment and Personnel:** Prepare tools, equipment, and personnel related to water management for flood-prone areas (before and throughout the rainy season). 6. **Improve Drainage System Efficiency:** Enhance the efficiency of drainage systems along major roads and transport routes (before and throughout the rainy season). 7. **Ensure Safety of Dams and Water Barriers:** Inspect and ensure the stability and safety of dams, dikes, and water barriers (before and throughout the rainy season). 8. **Prepare Emergency Plans and Response Centers:** Develop emergency response plans and set up centers to handle emergencies and aid in recovery from disasters (throughout the rainy season). 9. **Accelerate Development and Water Storage:** Accelerate the development and water storage in reservoirs to prepare for the dry season (starting from October to November). 10. **Strengthen Community Networks:** Strengthen community networks to provide relevant and timely information on weather and flooding conditions (before and throughout the rainy season). 11. **Raise Awareness and Educate the Public:** Carry out public awareness campaigns and educate communities on how to handle the rainy season (before and throughout the rainy season). 12. **Monitor and Evaluate Implementation:** Monitor and assess the effectiveness of these measures to ensure continuous improvement (throughout the rainy season).
Measure	(2) Increase the efficiency of drainage. (3) Develop an urban flood protection system by creating a water plan and drainage plan at the river basin, province, and city levels.
Responsible agencies	ONWR
Progress related to Measure	ONWR has developed water resource maps for 22 main river basins to provide recommendations for land use related to water systems. The chart will support the plan on the prevention and resolution of drought and the plan on the prevention and resolution of flood, as well as the allocation, use, development, management, maintenance, rehabilitation, and conservation of water resources in the river basin area. Establish a database system and an information system related to the water chart such as Geographic Information Systems (GIS) and Management Information Systems (MIS) for all parties to access and benefit from. **Available access data:** https://waterchartmis.onwr.go.th/wcmis/index.html

	
Approach 2-2: Midstream and downstream management (Drought management)	
Measure	(1) Develop database systems on the water footprint, water budget, and water demand of each sector in all of Thailand’s 22 main river basins.
Responsible agencies	ONWR
Progress related to Measure	ONWR will study, research, analyze, design, and develop a water resource management data warehouse system. Set data standards for water resource information and establish data sharing and exchange with relevant agencies. Additionally, integrate efforts between related agencies to support water resource management and decision-making by the NWRC and the River Basin Committees.
Measure	(2) Increase effectiveness in water budget and water retention management by setting a water usage ratio for each sector taking into consideration the amount of runoff and reserved water in each of Thailand’s 22 main river basins.
Responsible agencies	NWRC
Progress related to Measure	Thailand has developed a Seasonal Water Resource Management Plan for more effective water resource management and better response to the varying demands throughout the seasons, including: 1. **Forecasting Water Availability**: Use statistical data and forecasting techniques to estimate the amount of water available at the beginning of each season, at the national, provincial, and watershed levels. 2. **Developing Water Allocation Plans**: Establish methods for allocating water according to various usage activities such as agriculture, consumption, and industry, based on the forecasted water availability. 3. **Implementing the Plan**: Continuously monitor and adjust the water allocation plan based on actual conditions and changes in water availability.

	4. **Assessment and Improvement**: Evaluate the effectiveness of the management plan and make necessary adjustments to enhance water management efficiency.
Measure	(4) Increase effectiveness in the conjunctive management of surface water and groundwater in drought prone areas.
Responsible agencies	MOAC, MNRE, MOI, MDES, MHESI, ONWR, Ministry of Energy, Ministry of transport, MIND, Royal Initiative Discovery Foundation, NBTS, and PRD
Progress related to Measure	Measures for handling the dry season, include identifying areas at risk of water shortages for consumption, agriculture, and water quality in year 2023. It is categorized into 3 supply, 4 demand, and 3 management measures. **Supply** 1. Increase water storage. 2. Identify new water sources and prepare equipment. 3. Implement water supply projects. **Demand** 1. Designate water management and drought-prone areas. 2. Improve water efficiency in agriculture. 3. Prepare water supply for drought-affected regions. 4. Monitor water quality. **Management** 1. Strengthen local water management. 2. Promote public awareness. 3. Monitor and evaluate the progress of these efforts to ensure their effectiveness.
Approach 3: Downstream water management	
Measure	(4) Increase effectiveness in managing saltwater intrusion caused by the changing sea level, drought, and changes in runoff from human activities.
Responsible agencies	ONWR
Progress related to Measure	Thailand has developed guidelines to address the issues of saltwater intrusion, flooding, and drought in the river basins adjacent to the Gulf of Thailand. These guidelines include urgent, medium-term, and long-term measures, allowing relevant sectors to jointly consider solutions to the problem of saltwater intrusion in the river basins. The aim is to prevent and resolve the issue of saltwater encroachment in four river basins near the Gulf of Thailand: the Chao Phraya River Basin, Tha Chin River Basin, Bang Pakong River Basin, and Mae Klong River Basin.
Approach 4: Supporting mechanisms for water resources management	
Measure	(3) Develop a system for water forecasting and reporting.
Responsible agencies	ONWR and Hydro-Informatics Institute (Public Organization) (HII)

<table>
<tr><td>Progress related to Measure</td><td>
1. There is a system in place for forecasting weather data, as well as predicting water-related situations, to support water resource management planning, operated by ONWR and HII.
- Available access data: https://nationalthaiwater.onwr.go.th/


2. Procure licenses for water-related data processing software for handling large-scale water data, ensuring efficient water and spatial resource management, covering 22 main river basins in Thailand.
3. Implement support systems that apply artificial intelligence to develop river flow models, integrating flood prediction simulations from relevant agencies with water flow mapping, covering 22 main river basins in Thailand.
</td></tr>
<tr><td>Measure</td><td>(4) Integrated risk mapping in the form of One Map created together by the relevant agencies to predict climate change impacts on water resources management.</td></tr>
<tr><td>Responsible agencies</td><td>ONWR</td></tr>
<tr><td>Progress related to Measure</td><td>
1. A map of drought-prone areas for the dry season has been developed by assessing and forecasting areas at risk of water shortages during the dry season. This was done in collaboration with relevant agencies responsible for domestic water supply (such as the Provincial Waterworks Authority and the Department of Local Administration) and the agricultural sector (including the Department of Water Resources and the Department of Agricultural Extension). The purpose is to identify high-risk areas for the agencies to prepare for the situation before the season begins. Additionally, ongoing monitoring and surveillance of these risk areas will continue throughout the season.
2. The integration of the One Map rainfall mapping is carried out by TMD in collaboration with HII. This initiative uses monthly rainfall forecast data from the ONEMAP system to predict climate conditions, rainfall, water flow, reservoir levels, and hazard-prone areas, covering 22 main river basins in Thailand.
</td></tr>
</table>

Measure	(5) Develop water resources management plans, river basin master plans, and operation plans.
Responsible agencies	ONWR
Progress related to Measure	1. In 2024, Thailand has developed a water allocation plan that includes plans at the river basin level and drives the implementation through mechanisms such as river basin committees and sub-committees under these committees. The process involves representatives from various agencies, water users in agriculture, industry, and commerce, as well as local experts, across all 22 major river basins in the country. 2. ONWR Implements the Revised 20-Year Water Resource Management Master Plan (Phase 1 Adjustment, 2023–2037).
Measure	(6) Build disaster watch networks in risk areas by strengthening the capacities of the general public from the household to national levels.
Responsible agencies	ONWR
Progress related to Measure	Measures for handling the rainy season have been established to address the rainy season by strengthening community networks for information sharing. This involves providing knowledge to local communities for monitoring and surveillance, creating networks, and establishing channels for reporting and informing about local conditions. Additionally, local disaster prevention and mitigation plans have been practiced. The Department of Local Administration has already conducted emergency response drills at 121 local sites.

4.4.2 Agriculture and Food Security Sector

Table 4-5: Progress on implementation of adaptation under agriculture and food security sector.

Approach 1: Management of crop farmland	
Measure	(1) Encourage adjustment in agricultural patterns in response to the changing climate.
Responsible agencies	Royal Irrigation Department (RID), Department of Agricultural Extension (DOAE), and Agricultural Research Development Agency (Public Organization) (ARDA)
Progress related to Measure	**RID** Promotes the use of water for wet and dry rice cultivation during the off-season or during dry spells in irrigation areas, aiming to increase efficiency and water conservation, and reduce losses in rice cultivation amidst changing climate conditions. **DOAE** Promotes the enhancement of farmers with agricultural areas benefiting from irrigation system development. **ARDA**

	1. Development of a system for recommending optimal planting periods for rice and corn on maps for proactive management to adapt to climate change. 2. Development of guidelines for predicting optimal planting start dates for economic crops in the Khlong Suan Mak watershed for climate change adaptation. 3. Water management through a salinity forecasting system for planning cultivation in the Songkhla Lake Basin to accommodate climate change.
Measure	(3) Develop and improve water resources management in irrigated zones in flood risk and drought risk areas to be more effective.
Responsible agencies	RID, and DOAE
Progress related to Measure	**RID** Improving Water Demand Management Policies to Enhance Water Use Efficiency. **DOAE** Promoting Water Use Efficiency at the Farm Level to Enhance Water Efficiency Among Farmers.
Measure	(4) Develop water resources in non-irrigated zones to be more effective and sufficient to meet the demand for crops and livestock.
Responsible agencies	RID, and Land Development Department (LDD)
Progress related to Measure	**RID** Developing Water Sources and Expanding Irrigation Areas to Ensure Fair and Comprehensive Water Access for Farmers by constructing medium-sized irrigation projects, building small-scale water sources and distribution systems in community/rural areas, and developing flood retention projects. **LDD** Constructing water sources in non-irrigated farming areas to enhance water storage efficiency for agricultural use, alleviate drought, and increase productivity and income for farmers.
Measure	(5) Promote measures for soil conservation, rehabilitation, and soil fertility maintenance in degraded agricultural land, such as undertaking cover cropping, contour tillage, and crop selection according to the soil and climatic conditions in degraded agricultural land to increase production per unit, strengthen food security, and enhance the productivity of the areas.
Responsible agencies	LDD and ARDA
Progress related to Measure	**LDD** Promoting Soil Conservation, Restoration, and Maintenance through the following activities: 1. Enhancing efficiency and development of land use (specific areas). 2. Planning land management in agricultural risk areas.

	3. Improving acid soil areas. 4. Improving soil quality in problem areas and promoting the development of saline soil areas. 5. Improving soil quality in problem areas and developing sour soil areas. 6. Soil management and laboratory soil analysis. 7. Promoting plowing and organic fertilizer production to reduce greenhouse gas emissions. **ARDA** Integrating the Management Systems for Soil, Water, and Air Resources to Reduce Disaster Risks in Agricultural Areas under Climate Variability and Change to Support Sustainable Modern Agriculture: A Case Study in Maha Sarakham Province.
Approach 4: Supporting mechanisms for agriculture and food security	
Measure	(2) Develop an early warning system for the agricultural sector, which is accurate, easily accessible, timely, and linked effectively with other early warning systems.
Responsible agencies	ARDA
Progress related to Measure	1. Developing a Drought Monitoring and Forecasting System for Agricultural Areas in the Upper Northern Region of Thailand. 2. Developing a Prototype for Disaster Forecasting (Floods and Droughts) in the Mekong Basin's Northeast Region using Geographic Information Systems and Artificial Intelligence Platforms for Water Management in Irrigated and Non-Irrigated Agricultural and Rural Areas.
Measure	(3) Map climate-risk agricultural areas and climate change impacts at the local level and make the information available for farmers to access and apply.
Responsible agencies	LDD
Progress related to Measure	Developing Disaster Maps (drought, flooding, landslides, recurring droughts, recurring floods) and Planning Land Management in Agricultural Risk Areas of Thailand.
Measure	(5) Promote agro-economic zoning using a proactive Agri-map and mega farm systems for total production.
Responsible agencies	LDD and DOAE
Progress related to Measure	**LDD** Developing Land to Support Production Changes in Areas Unsuitable for Agriculture according to Agri-Map (Zoning by Agri-map) in Thailand's Cultivated Areas. **DOAE** Managing Agricultural Production According to the Agri-Map for Proactive Management in Thailand.

Measure	(6) Promote production with New Theory Agriculture, Sustainable Agriculture, and Integrated Farming to produce sufficient food for household consumption, reduce the risk of food shortages, and always have access to food.
Responsible agencies	OAE
Progress related to Measure	Sustainable agriculture has been developed, and in 2022, 76 farmer groups with a total of 1,487 members nationwide participated in the grouping and networking activities under the Sustainable Agriculture Development Project.
Measure	(9) Promote the improvement of crop/livestock varieties to accommodate the changes in climatic conditions and support farmers' access to these varieties.
Responsible agencies	ARDA
Progress related to Measure	1. Selecting and Propagating Drought-Tolerant Bamboo as a Substitute Crop for Bare Hillside Areas. 2. Developing High-Yielding and Heat-Tolerant Potato Varieties in Thailand. 3. Evaluating and Selecting Salt-Tolerant Rice Varieties and Developing Appropriate Rice Production Technologies for Salt-Intruded Areas.
Measure	(13) Enhance farmers' awareness of climate change impacts on the agricultural sector and capacity building of farmers to adaptive and climate-risk management.
Responsible agencies	DOAE
Progress related to Measure	1. Promoting Water Use Efficiency at the Farm Level to Educate Farmers on Irrigation Based on Crop Water Needs and Soil Moisture Maintenance. 2. Developing E-learning on Plant Protection and Soil-Fertilizer Management in the Context of Global Warming (Adaptation & Mitigation). 3. Developing E-learning on Soil and Fertilizer Management Technologies and Innovations (e.g., compost, soil test-based fertilizers, etc.) (Adaptation & Mitigation). 4. Creating a VDO Clip on Case Study of Rice Field Land Adjustment using Laser Land Leveling (Adaptation & Mitigation). 5. Campaigning for Awareness Under the Concept "Agriculture Knowledge to Combat Disasters" by the Plant Disaster Monitoring and Problem Solving Center, covering pre-disaster, during disaster, and post-disaster situations, plant care and recovery, pest and disease prevention, and adaptation and impact reduction from climate change and disasters (Adaptation & Mitigation). 6. Campaigning for Awareness Under the Concept "Stop Burning in Agricultural Areas" (Adaptation & Mitigation).

4.4.3 Tourism Sector

Table 4-6: Progress on implementation of adaptation under tourism sector

<table>
<tr><th colspan="2">Approach 1: Management of natural tourism destinations</th></tr>
<tr><td>Measure</td><td>(1) Adjust the tourism calendar to correspond to the changing seasonal pattern.</td></tr>
<tr><td>Responsible agencies</td><td>Tourism Authority of Thailand (TAT)</td></tr>
<tr><td>Progress related to Measure</td><td>1. Promotional materials have been created to encourage weekday tourism, along with sales promotion activities in various areas. These initiatives aim to stimulate tourism operators and their partners to organize promotional activities during weekdays, thereby encouraging more travel and increasing income distribution during weekdays.
2. Promotional activities have been carried out to encourage tourists to visit Thailand during the Green Season under the "Amazing Green Season in Thailand" project. The aim is to increase the number of Middle Eastern tourists traveling to Thailand during this season, with a focus on spreading tourism to pilot provinces following “the CITY MARKETING” approach. Additionally, efforts have been made to enhance market promotion in collaboration with partners to further stimulate travel to Thailand during the Green Season.</td></tr>
<tr><th colspan="2">Approach 3: Supporting mechanisms for tourism</th></tr>
<tr><td>Measure</td><td>(4) Develop and diversify activities in tourism destinations with high potential in order to build resilience and minimize the impacts of climate change.</td></tr>
<tr><td>Responsible agencies</td><td>Department of Tourism (DOT), Designated Areas for Sustainable Tourism Administration (Public Organization) (DASTA), and The Chiang Rai Provincial Office of Tourism and Sports</td></tr>
<tr><td>Progress related to Measure</td><td>DOT and DASTA
DOT is promoting Low Carbon Tourism routes to raise awareness among tourists, operators, and stakeholders about energy use and environmental impact. The goal is to ensure high-quality tourism, sustainability, and community engagement. The initiative includes establishing standards for low carbon tourism, offering practical training, and developing low carbon tourism routes.
Currently, DASTA is working to develop and elevate the Koh Mak area in Koh Kut District, Trat Province, as a sustainable destination. Koh Mak was recognized as one of the world’s top 100 sustainable destinations for 2022 in the Good Practice Story and Government, Reset & Recovery categories.</td></tr>
</table>

	The Chiang Rai Provincial Office of Tourism and Sports - The Chiang Rai Provincial Office of Tourism and Sports has developed a green tourism network based on the Circular Economy to address global climate change. The key objectives are: **1. To establish a green tourism network**: This network promotes collaboration in activities that stimulate and circulate the local economy (Circular Economy) with an emphasis on participatory environmental management. It aims to directly and indirectly support efforts to reduce haze pollution and achieve net-zero greenhouse gas emissions. **2. To organize Green Activities**: These activities aim to raise awareness of environmental management, waste management, and public health, while also stimulating the economy through local green tourism initiatives. **3. To promote and raise awareness**: This involves publicizing the project to residents, business operators, and tourists, fostering an understanding and awareness to halt activities that contribute to global climate change in provinces within the Lanna Civilization Tourism Development Zone. Currently, workshops have been conducted to strengthen the green tourism network for sustainable tourism development. Green tourism route guides have been created, FAM trips for tour agents and media have been organized, and green tourism network fairs have been held in the provinces of Chiang Rai, Phayao, Lamphun, Lampang, and Chiang Mai.
Measure	(5) Strengthen communities' and LAOs' capacity to manage diverse climate resilient tourism activities.
Responsible agencies	DOT, TAT and DASTA
Progress related to Measure	**DOT** 1. DOT has launched the Community-Based Tourism (CBT) Smart Environment project to promote and support CBT by encouraging the application of digital technology for the efficient management of natural resources and the environment within communities. Additionally, to enhance the capabilities of these tourism communities, ensuring they meet standards for responsible tourism that are socially and environmentally conscious. It is currently being implemented in 8 pilot communities. 2. DOT has initiated The Model Eco-friendly Accommodations Development Project. The project includes the establishment of quality criteria for eco-friendly tourist accommodations, training programs to enhance

	knowledge and skills in developing such accommodations, and the promotion and elevation of 20 model eco-friendly accommodations. **TAT** 1. TAT has implemented the Sustainable Tourism Acceleration Rating (STAR) project to elevate tourism operators to sustainable tourism standards. This initiative encourages collaboration in developing Thai tourism according to the Sustainable Tourism Goals (STGs), which are adapted from the SDGs. The STGs are tailored to fit the Thai tourism context and reflect the role of the Thai tourism sector in striving for sustainable development. Currently, 758 businesses have been awarded the STAR certification for meeting these standards. 2. TAT has developed the CF-Hotels project which serves as a tool for creating Big Data through an environmental accounting system. It is part of an initiative aimed at enhancing the capabilities of eco-friendly hotel and accommodation operators. The project seeks to establish a network of businesses that operate in an environmentally friendly manner, encouraging and supporting activities to reduce GHG emissions in the hotel and accommodation sectors. Additionally, it focuses on raising awareness of carbon reduction efforts among hotels and accommodations throughout Thailand. **DASTA** - DASTA is currently conducting studies and developing the capacity of communities in tourist destinations to enhance their ability to manage the risks of tourism ecosystems affected by climate change sustainably.
Measure	(8) Raise awareness and educate tourists about climate risks and the vulnerabilities of tourism destinations.
Responsible agencies	DOT
Progress related to Measure	DOT is currently engaging in activities to communicate and promote responsible tourism and environmental and social responsibility.

4.4.4 Public Health Sector

Table 4-7: Progress on implementation of adaptation under public health sector

Approach 1: Preventing climate change health impacts	
Measure	(3) Strengthen the capacity of the general public by creating knowledge, understanding, and awareness on climate change related health impacts, and promote public participation in proper climate change adaptation and management.
Responsible agencies	DOH
Progress related to Measure	1. DOH has enhanced health literacy, public health, and sanitation at establishments to address the COVID-19 pandemic. They have developed and produced communication materials on eight topics and their information has reached the public 15 million times via the DOH's Facebook page. 2. DOH has launched a project to enhance health adaptation to climate change, focusing on the following activities: - **Developing Guidelines**: Creating guidelines for environmental health literacy to address climate change impacts (flooding, drought, heat) and air pollution for communities and the elderly. - **Assessment Tools**: Developing assessment tools for environmental health literacy to mitigate health impacts and promote healthy behaviors in response to climate change and air pollution. - **Raising Awareness**: Promoting awareness among at-risk populations based on local contexts through community health centers. - **Ongoing Work**: Currently working on increasing and evaluating environmental health literacy within 26 communities.
Approach 2: Supporting mechanisms for public health	
Measure	(1) Develop surveillance and forecast systems for climate change related health impacts.
Responsible agencies	DOH
Progress related to Measure	1. DOH is implementing a project to enhance health adaptation to climate change with the following activities: - **Monitoring and Communication**: Monitoring and communicating health warnings related to heat using the Heat Index in collaboration with

	relevant agencies such as the Meteorological Department, the Royal Thai Army Medical College, the Disease Control Department, the Climate Change Department, and the Department of Health. - **Public Awareness**: Promoting the monitoring and communication of heat health warnings using the Heat Index to the public. - **Risk Monitoring and Prevention**: Monitoring heat-related symptoms and preventive behaviors through health surveys. The surveys have identified that the most common heat-related symptom among the public is headaches. The findings are used to inform health centers and provincial public health offices to improve heat monitoring and communication systems. 2. DOH has established guidelines for monitoring and preventing health impacts from air pollution, specifically PM2.5, using the principles of "Health Promotion, Disease Prevention, and Health Literacy." These guidelines cover four key measures: - **Measure 1 Promoting Pollution Reduction and Health Literacy:** Establishing the Air Pollution Health Impact Resolution Center and launching hotlines (1422 and 1478) to provide information and assistance. - **Measure 2 Reducing and Preventing Health Impacts:** Monitoring air quality and issuing health risk warnings, along with guidance on appropriate behavior for the public. Coordinating with relevant agencies to limit outdoor activities when necessary. - **Measure3 Medical and Public Health Services:** Promoting dust-free rooms in health services, schools, daycare centers, and private sector facilities such as malls and restaurants. Encouraging dust-free spaces in homes. - **Measure4 Enhancing Management Efficiency:** When PM2.5 levels exceed 37.5 µg/m³, provincial authorities should activate emergency response centers for medical and public health emergencies related to smog and fine dust. This includes enforcing laws under the Public Health Act.
Measure	(6) Strengthen the capacity of public health officials at all levels on pro-active responses to climate change.
Responsible agencies	DOH
Progress related to Measure	1. Has developed a curriculum and tools aimed at enhancing the capacity of public health officers (known as "Master Trainers") to adapt to climate change. This curriculum consists of six modules: - **Module 1**: The Importance of Climate Change

	- **Module 2**: Health Impacts from Climate Change - **Module 3**: Risk and Vulnerability Assessment - **Module 4**: Climate Change Adaptation Strategies - **Module 5**: Low-Carbon Health Systems - **Module 6**: Developing Health Adaptation Plans for Climate Change - In addition, the department has been building the capacity of public health officers to become "Master Trainers" in climate change adaptation. These capacity-building activities include training central department staff, health officers from Regional Health Centers 1-12, the Urban Health Promotion Institute, Provincial Health Offices, and local administrative organizations in climate-vulnerable areas. These efforts are designed to equip public health professionals with the skills to effectively address climate change impact on health. 2. DOT has developed a Family Care Team Handbook focused on climate change and health awareness, particularly in the context of heat-related issues. This guide is designed for Family Care Teams at the sub-district level or health promotion hospitals and all primary care units. It provides a framework for organizing activities that raise public awareness and help prevent health impacts due to climate change, especially heat. Capacity building is offered for Family Care Teams to understand climate change and its health implications, specifically heat-related risks. They are then responsible for relaying this knowledge to Village Health Volunteers, who further disseminate the information to the community. Moreover, supporting PACKIT Educational Tools, materials are provided to Family Care Teams to facilitate communication and raise climate change and health awareness, particularly heat risks, among the public. The tools are distributed to 52 health service units located in areas vulnerable to heat, ensuring effective public outreach in these high-risk zones. 3. DOT has developed a Low-Carbon and Climate-Resilient Hospital Curriculum. The tools for assessing vulnerability and impacts from climate change-related disasters have also been developed, including floods, storms, droughts, and heatwaves. Additionally, knowledge has been provided to healthcare personnel to raise awareness, enabling them to assess the vulnerability of hospitals across 25 healthcare facilities.
Measure	(7) Develop cooperation mechanisms among all sectors inside and outside the public health system to prevent and reduce health impacts from climate change.
Responsible agencies	DOT

Progress related to Measure	1. A Memorandum of Understanding (MOU) was signed on "The Application of Geo-Informatics and Space Technology for Developing Spatial Health Research and Services" between the Geo-Informatics and Space Technology Development Agency (GISTDA) and the DOH. The scope of cooperation includes: - Research and analysis for the development of spatial health research and services using space technology and geoinformatics. - Exchange and support of data and knowledge resources. - Promotion and development of personnel from both sides to enhance their knowledge and skills in applying space technology and health research. As a result of the MOU, both parties have jointly developed the Life Dee (LifeD) application, which alerts users about PM2.5 air quality levels, provides information on health impacts, self-protection guidelines, an online pollution clinic, and nearby dust-free rooms. 2. An MOU on Cooperation for the Integration of Operations in the Development of Academic and Research Areas on Climate Change in Public Health was signed between DOH and TMD. The scope of the collaboration includes: - Integrating information management systems to improve efficiency. - Jointly developing health surveillance and forecasting systems to warn of future impacts caused by climate change. - Promoting health literacy among the public to help them cope with and adapt to climate and meteorological changes. - Enhancing the capacity of personnel in both climate change and public health operations. - Integrating academic and research development efforts. - As a result of the MOU, the following initiatives have been jointly developed: - Health surveillance and heat hazard warnings using the Heat Index. - Integrating capacity-building for public health personnel and local administrative organizations - Research on rainwater quality for consumption - Knowledge exchange on climate change and public health through conferences and academic seminars.

4.4.5 Natural Resources Management Sector

Table 4-8: Progress on implementation of adaptation under natural resources management sector.

Approach 1: Management of terrestrial ecosystems	
Measure	(1) Conserve pristine protected areas through an ecosystem-based approach by creating ecological corridors and developing buffer zone management.
Responsible agencies	ONEP
Progress related to Measure	1. ONEP develops a set of core indicators to assess the status of watershed classifications at the national level, aiming to effectively evaluate the overall condition of natural resources and the environment within river basions. 2. Land use change in the upstream watershed areas (watershed classes 1 and 2) are analysed to assess the current status of natural resources conditions. 3. Policy recommendations are developed to support effective watershed management towards sustainability in these areas. Currently, Thailand is in the process of gathering additional information to revise policy recommendations for protection, restoration, and utilization of the entire upstream watershed management.
Measure	(2) Promote reforestation and afforestation with appropriate incentives, such as carbon credits in encroached areas, degraded watersheds, or vacant land outside natural forests, including private forests.
Responsible agencies	ONEP
Progress related to Measure	ONEP has formulated natural resource and environmental protection plans for upstream watershed areas in collaboration with local communities. These plans include 1) Phatthawi Subdistrict, Makham District, Chanthaburi Province (representing a balanced watershed status) and 2) Mae Phun Subdistrict, Laplae District, Uttaradit Province (representing a critical status). Both plans serve as frameworks that align with watershed status assessments and address key issues.
Measure	(4) Support the conservation of endemic and endangered species in terrestrial ecosystems, especially carnivores, affected by climate change, as well as prevent invasive alien species, which could become widespread due to the changing climatic conditions.
Responsible agencies	ONEP
Progress related to Measure	Thailand is currently drafting subordinate legislation under the (Draft) Biological Diversity Act, B.E. ..., to facilitate the proper implementation and management of biodiversity. The draft is presently under review by the Council of State.

	A draft of the criteria for selecting areas with unique species has been preliminarily completed and is awaiting submission to the Biodiversity Technical Subcommittee for consideration. Additionally, efforts are underway to develop criteria and guidelines for assessing the abundance of terrestrial ecosystems and to draft conservation plans for species and ecosystems in two pilot areas.
Approach 3: Management of marine and coastal ecosystems	
Measure	(1) Conserve and protect marine and coastal resources, including increasing and rehabilitating mangrove areas for an ecological balance through a participatory approach. (7) Enable networks of people organizations, community-based organizations, and LAOs along the coastal zones to conserve and rehabilitate marine and coastal resources.
Responsible agencies	ONEP
Progress related to Measure	ONEP is currently supporting policy and technical efforts to promote the conservation of marine and coastal biodiversity. This is being carried out under the Climate Coastal and Marine Biodiversity (CCMB) project, which integrates climate change adaptation with sustainable tourism. The project applies the Other Effective Area – Based Conservation Measures (OECM) tool to promote the protection, conservation, and monitoring of coastal ecosystems. It integrates climate mitigation and adaptation with sustainable tourism promotion, raising awareness, educating, and building capacity across all levels and sectors. The outcomes will be used to inform policy decisions and provide valuable data for further action.
Measure	(2) Support the conservation of endemic and endangered species in marine and coastal ecosystems affected by climate change, as well as prevent invasive alien species, which could become widespread due to the changing climatic conditions.
Responsible agencies	ONEP
Progress related to Measure	Thailand is currently drafting subordinate legislation under the (Draft) Biological Diversity Act, B.E. ..., to facilitate the proper implementation and management of biodiversity. The draft is presently under review by the Council of State. A draft of the criteria for selecting areas with unique species has been preliminarily completed and is awaiting submission to the Biodiversity Technical Subcommittee for consideration. Additionally, efforts are underway to develop criteria and guidelines for assessing the abundance of marine and coastal ecosystems and to draft conservation plans for species and ecosystems in two pilot areas.
Measure	(3) Expedite the designation of the EPAs in marine and coastal areas with fragile ecosystems and threats to biodiversity resources, which are outside the PAs.
Responsible agencies	ONEP

Progress related to Measure	ONEP is implementing a project to enhance the management efficiency of environmentally protected areas. This involves analyzing and evaluating the effectiveness of environmental protection measures in declared protected areas. The focus is on areas in Bang Lamung District and Sattahip District, Chonburi Province. Recommendations for improving these environmental protection measures are being made alongside the drafting of new notifications of the MNRE. This declaration outlines the boundaries and protection measures for these districts. The draft is currently under review by the Subcommittee on Environmental Management in Protected Areas.
Approach 4: Supporting mechanisms for natural resources management and biodiversity	
Measure	(6) Develop mechanisms to promote the role of ecologically friendly communities in preserving and conserving natural resources and ecosystems.
Responsible agencies	ONEP
Progress related to Measure	A project is being driven to apply economic mechanisms and incentives for the conservation of Migratory Waterbirds and the sustainable utilization of their habitats. This involves reviewing laws, regulations, ordinances, and related measures that support Migratory Waterbirds conservation. Relevant networks and agencies are holding meetings to develop conservation measures for both the birds and their habitats. Additionally, a waterbirds conservation tourism group has been established within the Krabi River estuary Flyway Network Site in Krabi Province to ensure practical implementation. Moreover, there are plans to assess the economic value in two dimensions: tourism and ecosystem services. There is also a focus on building the capacity of local communities to enhance their involvement in the project.

4.4.6 Human Settlement and Security Sector

Table 4-9: Progress on implementation of adaptation under human settlement and security sector.

Approach 1: Management of metropolitan and large cities	
Measure	(1) Develop the essential infrastructure with alternatives to prepare for emergencies caused by natural disasters, and develop emergency response plans through a participatory approach in all risk areas, as well as disseminate the information to the general public, so that they would be aware and able to take action.
Responsible agencies	DPT
Progress related to Measure	The following laws and regulations have been announced and enforced: 1. Building Control Act (1979)

	2. Ministerial Regulation on Specifying the Load Bearing, Resistance, and Durability of Buildings and the Supporting Ground for Earthquake Resistance (2021) 3. Notification of the Ministry of Interior on the Design and Calculation of Building Structures for Earthquake Resistance 4. Ministerial Regulation on the Design of Building Structures and the Characteristics and Properties of Materials Used in Building Structures, B.E. 2566 (2023) In addition, the DPT is also in the process of issuing further notification to specify the design of building structures and the characteristics and properties of materials used in construction.
Measure	(2) Advocate for town planning regulations or building control laws in potential climate change impact areas to ensure that built structures are stable, secure, and appropriately designed to enhance climate resilience.
Responsible agencies	DPT
Progress related to Measure	The DPT is currently studying guidelines for building control and developing a manual of measures for buildings to adapt to and prepare for climate change (Adaptation and Resilience).
Measure	(4) Develop additional green multi-use spaces that are connected within the city as well as to nearby areas to mitigate the climate-related impact.
Responsible agencies	ONEP, Local government organization, Department of Local Administration, MOI, and National Municipal League of Thailand
Progress related to Measure	ONEP issued operational guidelines to drive the sustainable management of green spaces, Phase 2 (2023-2027). These guidelines will serve as a framework for relevant agencies and sectors to conserve and develop green and open spaces, aiming to balance ecosystems and enhance the quality of life for communities and urban environments. The goal is to ensure that municipalities or local administrative organizations across Thailand provide at least 10 square meters of public green space per person and that green space constitutes no less than 10% of urban areas.
Approach 2: Management of medium and small cities and communities	
Measure	(4) Develop land use plans that preserve areas of high environmental/ecosystem value, including agricultural land, water resources, and green spaces to sustain ecosystems and address floods and drought.
Responsible agencies	ONEP, Royal Forest Department (RFD), municipalities, and subdistrict administrative organizations
Progress related to Measure	ONEP, in collaboration with the RFD, municipalities, and subdistrict administrative organizations, is working on creating conservation plans for specific categories of cultural heritage sites and ecological zoning maps for natural hot spring areas in the lower northern region of Thailand. The areas include: 1. Samo Thong Hot Springs, Thong lang Subdistrict, Huai Khot District, Uthai Thani Province

	2. Ministerial Regulation on Specifying the Load Bearing, Resistance, and Durability of Buildings and the Supporting Ground for Earthquake Resistance (2021) 3. Notification of the Ministry of Interior on the Design and Calculation of Building Structures for Earthquake Resistance 4. Ministerial Regulation on the Design of Building Structures and the Characteristics and Properties of Materials Used in Building Structures, B.E. 2566 (2023) In addition, the DPT is also in the process of issuing further notification to specify the design of building structures and the characteristics and properties of materials used in construction.
Measure	(2) Advocate for town planning regulations or building control laws in potential climate change impact areas to ensure that built structures are stable, secure, and appropriately designed to enhance climate resilience.
Responsible agencies	DPT
Progress related to Measure	The DPT is currently studying guidelines for building control and developing a manual of measures for buildings to adapt to and prepare for climate change (Adaptation and Resilience).
Measure	(4) Develop additional green multi-use spaces that are connected within the city as well as to nearby areas to mitigate the climate-related impact.
Responsible agencies	ONEP, Local government organization, Department of Local Administration, MOI, and National Municipal League of Thailand
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Measure	(4) Develop land use plans that preserve areas of high environmental/ecosystem value, including agricultural land, water resources, and green spaces to sustain ecosystems and address floods and drought.
Responsible agencies	ONEP, Royal Forest Department (RFD), municipalities, and subdistrict administrative organizations
Progress related to Measure	ONEP, in collaboration with the RFD, municipalities, and subdistrict administrative organizations, is working on creating conservation plans for specific categories of cultural heritage sites and ecological zoning maps for natural hot spring areas in the lower northern region of Thailand. The areas include:

	1. Samo Thong Hot Springs, Thong lang Subdistrict, Huai Khot District, Uthai Thani Province 2. Phra Ruang Hot Springs, Lan Dok Mai Subdistrict, Mueang Kamphaeng Phet District, Kamphaeng Phet Province Thailand still requires support in studying the impacts of climate change on various types of natural sites, including islands, rapids, mountains, caves, waterfalls, geological formations, fossils, beaches, hot springs, and water sources in all dimensions. This information is crucial for planning adaptation measures for climate change, which will be used in developing future ecological zoning maps.
Approach 3: Supporting mechanisms for human settlements and security	
Measure	(3) Expedite the integration of a climate-resilient building approach into the standards and regulations of building designs in the Building Control Act 1979 to be consistent with the changing climatic conditions and degrees of the severity of natural disasters in each area.
Responsible agencies	DPT
Progress related to Measure	The DPT has announced and enforced a ministerial regulation on the design of building structures and the characteristics and specifications of materials used in building structures (2023).

4.5 MONITORING AND EVALUATION OF ADAPTATION ACTIONS AND PROCESSES

4.5.1 The institutional framework for monitoring and evaluation of climate adaptation in Thailand

Thailand acknowledges that M&E are essential to the adaptation planning process, as they support decision-makers in tracking the benefits of adaptation interventions and building a resilient society. The objectives of adaptation M&E must be clearly defined at different stages of the planning process.

To effectively monitor and evaluate the adaptation process, Thailand has established an M&E framework focusing on three key aspects (Figure 4-2):

1. **Adaptation Planning:** The goal is to create long-term or sectoral plans that integrate climate adaptation measures. The M&E approach focuses on tracking the integration of adaptation issues into these plans, which include high-risk sectors, vulnerable areas, climate hazards, and relevant agencies.

2. **Adaptation Implementation:** The goal is to implement measures and mechanisms that enhance resilience to climate change. The short-term M&E approach monitors progress and implementation of each measure, while the long-term approach assesses the effectiveness, efficiency, sustainability, broader impacts of these measures, and mitigation co-benefits.

3. **Adaptation Outcomes**: The goal is for sectoral socio-economic systems to develop resilience to climate change. The M&E approach monitors short-term vulnerabilities to climate hazards and long-term climate change impacts, adaptive capacity, and resilience, which are assessed using Climate Resilience Indicators (currently under development).

Additionally, Thailand has begun developing a system to monitor adaptation outcomes, including creating climate resilience indicators to track the country's resilience to climate impacts over the medium and long term. This process began in 2020 and is based on sector-specific indicators.

Adaptation Planning	Adaptation Implementation	Adaptation Outcome
	Goal for Adaptation M&E	
Concrete adaptation plan and long-term/sectoral plans with mainstreamed adaptation.	Adaptation actions and mechanisms to enhance deployed climate resilience.	Sectors and socio - economic system resilience to climate change.
	Approach for M&E	
Quantity and coverage of long term/sectoral plans with mainstreamed adaptation.	**Short-term** • Adaptation project progress as planned, and output/target reached. • Mechanisms to enhance resilience in place. **Long-term** • Effectiveness and efficiency of the adaptation project. • Sustainability of the adaptation project. • Cross sectors effect impact. • Mitigation co-benefits.	• Vulnerability to climate hazards (short term) and climate change (long term) reduced. • Adaptive capacity to climate change increased. • Resilience to climate change increased.

Figure 4-2: Thailand’s adaptation monitoring and evaluation framework

Source: Department of Climate Change and Environment (2023)

To ensure the effectiveness and consistency of this M&E system, a data collection and reporting structure has been established. Since August 2023, the DCCE has taken over the responsibility from ONEP. The DCCE now collaborates with focal agencies in six key sectors to report on M&E results, covering adaptation planning, implementation, and resilience status within each sector (Figure 4-3). (See the details of M&E in the NAP (Department of Climate Change and Environment, 2023) https://unfccc.int/sites/default/files/resource/NAP_THAILAND_2024.pdf.

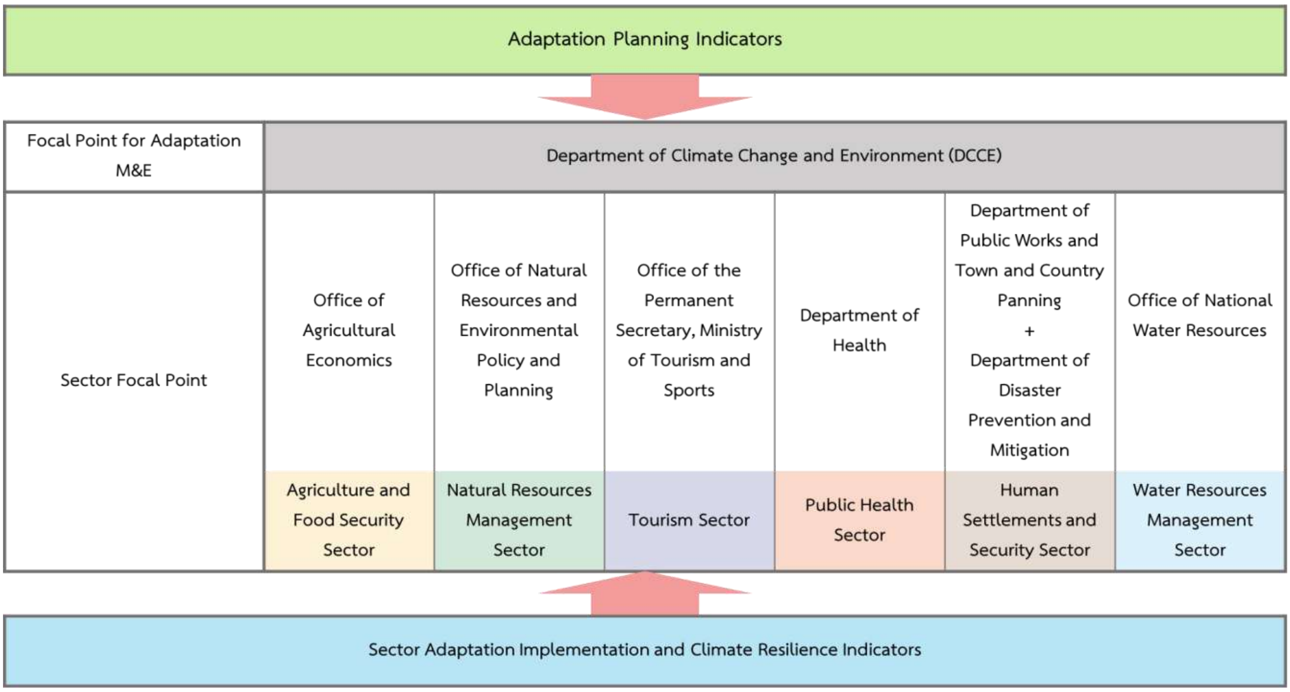

Figure 4-3: Sectoral focal point for Thailand's M&E adaptation actions

Source: Department of Climate Change and Environment (2023)

4.5.2 The progress of Adaptation Monitoring and Evaluation Processes

Following Thailand's adoption of the M&E framework, a system for monitoring and evaluating the NAP has been established. The DCCE has undertaken the following actions:

4.5.2.1 National Level

Currently, the DCCE is developing an approach for M&E climate change adaptation in alignment with the NAP and Thailand's specific context. This involves creating a reporting system, database, and evaluation framework for tracking the implementation of the NAP. The DCCE is collaborating with focal points across six key sectors and other relevant organizations to develop reporting and evaluation formats. These formats will detail the types of data, sources of information, responsible agencies, data collection methods, reporting periods, and evaluation procedures. This system aims to efficiently link sectoral adaptation efforts with the GGA. The steps are as follows (Figure 4-4):

1. **Setting Targets and Indicators:**
    - Establish clear, long-term targets that are achievable and relevant to climate change adaptation.
    - Define specific, quantitative indicators to measure the success of adaptation efforts.
    - Develop a combination of both quantitative and qualitative indicators for comprehensive evaluation.

2. **Data Collection:**
   - Collect relevant data, such as climate-specific information, impacts of climate change, and scientific baseline data.
   - Utilize tools like Geographic Information Systems (GIS) to analyze and identify high-risk areas.
3. **Analysis and Assessment:**
   - Analyze data to evaluate the impact of climate change on natural resources and society.
   - Assess potential problems and risks that may arise due to climate change.
4. **Reporting and Communication:**
   - Prepare adaptation reports based on the established targets.
   - Communicate the evaluation results and recommendations to relevant stakeholders, including international organizations and partner networks.
5. **Plan Improvement:**
   - Revise the implementation plan based on assessment results and recommendations.
   - Enhance data collection systems and analytical methods to improve the effectiveness of monitoring and evaluation.
6. **Implementation:**
   - Put the revised implementation plan into action.
   - Use data and analysis to support decision-making and promote beneficial activities for climate change adaptation.

Figure 4-4: Approach for M&E Climate Change Adaptation in Thailand According to GGA

Additionally, the DCCE is preparing a manual for monitoring and evaluating climate change adaptation that will be tailored to each sector according to the NAP. The department is also working to engage a network of experts and stakeholders from all relevant sectors at both regional and national levels.

4.5.2.2 Sectoral Level

The DCCE has carried out the project of M&E of climate change adaptation efforts in six pilot sectors. This includes developing criteria for selecting pilot areas for climate adaptation as well as creating M&E forms for local areas. The focus is on analyzing gaps in implementation, identifying problems and obstacles, and drawing lessons learned from the pilot areas with potential to provide guidelines and recommendations for other affected areas with similar risks and vulnerabilities. Additionally, this process aims to generate recommendations and feedback for integrating climate change adaptation issues at the regional level.

4.6 INFORMATION RELATED TO AVERTING MINIMIZING AND ADDRESSING LOSS AND DAMAGE ASSOCIATED WITH CLIMATE CHANGE IMPACTS

4.6.1 Thailand's Previous Efforts to Address Loss and Damage

Thailand has established mechanisms and regulation to reduce losses and damages from disasters, including key plans, regulations and process for disseminating disaster warnings as follows:

The Disaster Prevention and Mitigation Act (2007) was enacted to provide a framework and direction enabling all sectors to systematically manage disaster situations together. The DDPM serves as the central government agency responsible for disaster prevention and mitigation nationwide, with the following duties and responsibilities:

1) Develop the National Disaster Prevention and Mitigation Plan to be proposed to the National Disaster Prevention and Mitigation Committee (NDPMC) for approval by the Cabinet.
2) Conduct studies and research to identify effective measures for disaster prevention and mitigation.
3) Execute, coordinate, support, and assist operations of government agencies, local administrative organizations, and private sector entities in disaster prevention and mitigation. This also includes providing initial relief to disaster victims, those affected by hazards, and individuals suffering damage caused by disasters.
4) Provide advice, consultation, and training on disaster prevention and mitigation to government agencies, local administrative organizations, and private sector entities.
5) Monitor, inspect, and evaluate the implementation of disaster prevention and mitigation plans at all levels.

The National Disaster Prevention and Mitigation Plan (2021-2030) as detailed in session "Adaptation strategies, Policies, Plans, Goals and Actions to Integrate Adaptation into National Policies and Strategies under the topic of Human Settlements and Security sector".

The Regulations of the Ministry of Finance on Emergency Relief Advances for Disaster Victims (2019) aim to provide government agencies with a framework for advancing funds in urgent and necessary cases where it is not possible to wait for the budget allocation. Disaster refers to any public calamity, including fires, storms, floods, droughts, hail, forest fires, disease outbreaks, or any other event causing significant harm to life, health, or property. The regulations cover activities related to agriculture, social welfare, medical and public health, housing, safety, and occupational rehabilitation, with the goal of quickly alleviating the immediate distress of disaster victims. The key areas of assistance are as follows:

1) Agricultural Assistance

- This includes support for livestock and fisheries, ensuring the restoration of agricultural production impacted by disasters.

2) **Social Welfare and Disaster Victim Rehabilitation**

- Short-term assistance is provided, such as caring for children, the elderly, or disabled persons in cases where the family head has died, become disabled, or been injured due to the disaster. It also includes relocating families, short-term occupational support, and providing counseling and guidance.

3) **Medical and Public Health Assistance**

- This encompasses physical and mental health support, including medical treatment, health promotion, disease prevention and control, and rehabilitation, to help disaster victims return to normal living conditions as quickly as possible.

4) **Housing and Property Assistance**

- This involves repairing homes and property damaged by disasters to restore them to their original condition, thereby alleviating immediate distress.

5) **Safety and Security Assistance**

- Measures are taken to prevent further damage and provide assistance in emergencies that are anticipated to occur in the near future.

6) **Occupational Rehabilitation and Promotion**

- Assistance is provided to help disaster victims restore their livelihoods, enabling them to resume normal life.

A process for disseminating disaster warnings in Thailand, as shown in Figure 4-5, beginning with the collection of information from diverse domestic and international sources, including observation systems and regional data exchanges. This data is then meticulously analyzed by experts to evaluate potential hazards and determine whether to issue a warning. The early warning about disasters will alert various target groups, including operational units, the general public, individuals in at-risk areas, and international partners through various warning equipment and channels such as

1) 163 satellite alarm receivers (EVAC), which, by directly receiving warnings via satellite, are installed at provincial broadcasting stations and municipal halls to warn the province's citizens and government agencies.

2) The alarm relay station (CSC) has 285 locations, which are installed at subdistrict administrative organizations or government agencies in subdistricts where landslides and flash floods occur. The National Disaster Warning Center sends out warning signals by satellite, and they use radio waves to transmit the signal to the community's news broadcasting tower and alarm receiver.

3) 338 warning towers and 674 broadcasting towers to alert people to various catastrophes by using a siren and a recorded announcement.

4) Application “Thai Disaster Alert”, a mobile app designed to provide real-time alerts and information about natural disasters and emergencies in Thailand; alerts are location-based, ensuring that users receive relevant information for their specific area.

Available access application:
https://play.google.com/store/apps/details?id=com.THAIDAlert.DPM&hl=th

5) Social media platforms (LINE, Twitter and Facebook), Line alert is used to receive notifications about various natural disasters, including the ability to report issues or different types of disasters by adding the National Disaster Warning Center account as a friend on the LINE application.

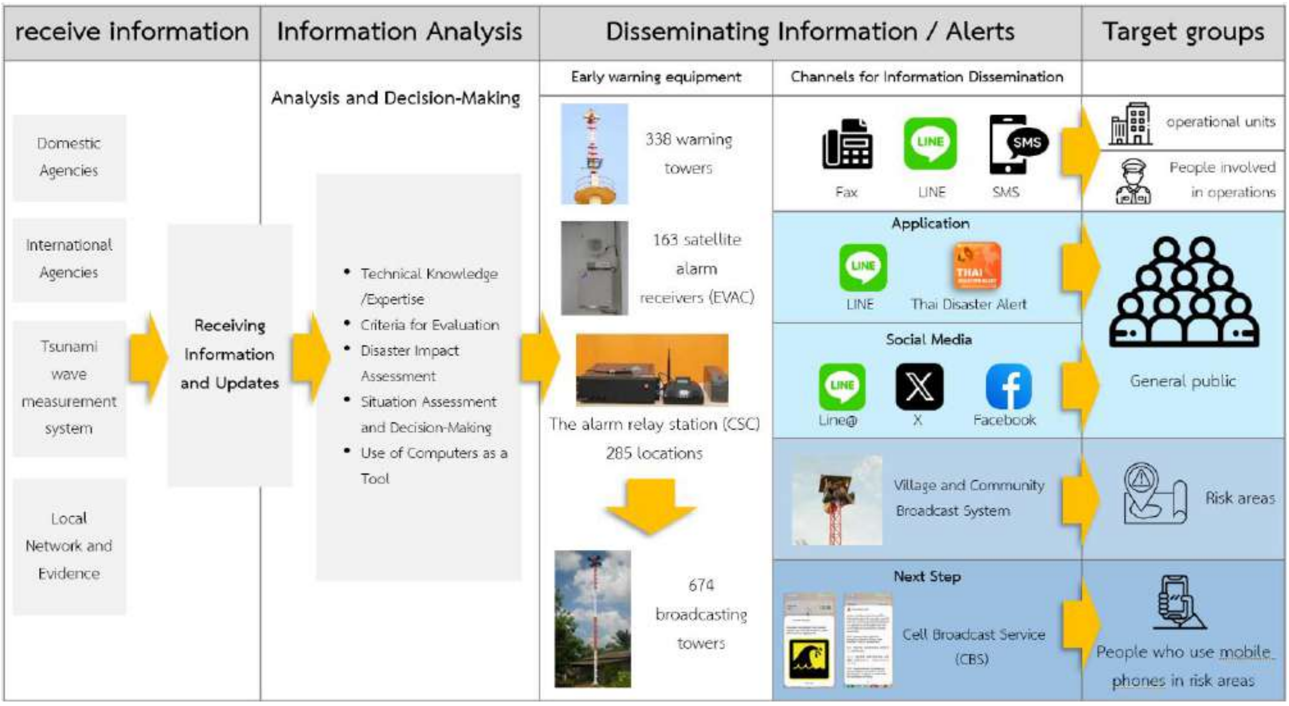

Figure 4-5: A comprehensive process for disseminating disaster warnings in Thailand

Source: Adapted from Department of Disaster Prevention and Mitigation (2023)

Moreover, Thailand also has developed mobile applications designed to alert and report on various types of disasters. These applications are critical tools for both authorities and the public, providing real-time information and enhancing disaster preparedness and response efforts. The following are the prominent disaster-related applications used in Thailand:

1) Application "DPM REPORTER" - The DDPM has launched the "DPM REPORTER" application. This new platform is designed to disseminate information on disaster situations, aiming to raise awareness and reduce risks and losses from disasters by enabling rapid warnings. The application serves as a medium for communicating disaster monitoring and warning information to the public through smartphones via both private and public channels.

This initiative integrates concepts of prevention, preparedness, and resilience building at the community level. It also incorporates international principles of disaster risk reduction, focusing on awareness and adaptability before, during, and after disasters. The main functions of the DPM REPORTER application include disaster news, incident reporting, news mapping, disaster alert notifications, and disaster statistics. The application will compile disaster occurrence data on an annual, monthly, weekly, and daily basis. It will facilitate faster and more timely information exchange between users and system administrators.

Available access application:
https://apps.apple.com/th/app/dpm-reporter/id977297308?l=th&platform=iphone.

2) Application "SWOC Monitor" - The Smart Water Operation Center Monitor (SWOC Monitor) application, developed by RID under the MOAC, is available for download on iOS operating systems. This application provides alerts, reports, and presents information on rainfall, large and medium-sized reservoirs, river flows, water quality, and disaster situations. Its functionalities include:

- **Rainfall Situation Alerts and Reports:** Delivers real-time notifications and reports on rainfall across different regions, helping users stay informed about current weather conditions.
- **Reservoir Water Situation Alerts and Reports:** Provides updates and warnings on the water levels in large and medium-sized reservoirs, ensuring that users are aware of potential risks related to water storage.
- **River Flow Situation Alerts and Reports:** Monitors and reports on river flow conditions, offering critical information on water levels in major rivers.
- **Water Quality Situation Alerts and Reports:** Tracks and alerts users to the quality of water in various water bodies, helping to monitor and manage water safety and environmental health.
- **Disaster Situation Reports and Assistance:** The app offers reports on disaster situations and the relief efforts managed by the Royal Irrigation Department, providing timely information on emergency responses.
- **Decision Support System (DSS):** Includes a DSS to aid in the management of water discharge from 35 major dams and monitors key river flow stations across 6 critical locations, assisting in decision-making processes related to water management and flood prevention.

Available access application: https://apps.apple.com/th/app/swoc-monitor/id1534269852

3) Application "EWS DWR" - The Department of Water Resources (DWR) has implemented an Early Warning System for flood and landslide-prone areas, particularly in sloped terrains and foothill regions. From the fiscal years 2005 to 2015, the department installed 1,546 early warning stations, covering 4,911 high-risk villages. In the fiscal year 2020, an additional 250 stations were installed to cover at least 571 more high-risk villages. This system is designed to monitor and provide early warnings for flash floods by measuring rainfall and/or water levels in high-risk villages.

In addition to on-site monitoring systems, the Early Warning System includes the development of applications for retrieving data from monitoring databases, analyzing situations, and providing forecasts and warnings without the need for manual data entry into analysis programs. The system also involves the development of mobile applications to display early warning results, allowing relevant data to be effectively utilized. With advancements in information and communication technology, as well as more stable and faster internet connectivity, accessing information via the internet has become easier. Therefore, there is a plan to develop an Early Warning System mobile application that operates on both android and iOS smartphones. This will enhance the convenience of monitoring and tracking early warning systems, making it easier to carry and quickly access the required information.

Available access application:
https://play.google.com/store/apps/details?id=com.ssoft.ews4thai&hl=th&gl=US

4) Application "DWR4THAI" - The DWR has developed a DWR4THAI Application to enhance public access to water situation reports and related services. This application integrates data from the existing water resources information system and presents information, news, and e-Services to the public via the Government Application Center. It also supports natural disaster monitoring, surveillance, and early warning, ensuring that citizens receive accurate, reliable, and transparent information, available on both Android and iOS systems. The key features of this application are as follows:

- **24-Hour Water Situation Monitoring:** Provides real-time monitoring and reporting of water situations, ensuring continuous access to up-to-date information.
- **Flood and Landslide Warning Menu:** Includes information on the date of the warning announcement and uses color-coded status indicators aligned with the early warning and monitoring system for floods and landslides.
- **Department of Water Resources Projects Menu:** Offers detailed information about various projects undertaken by regional water resource offices.
- **Knowledge Base Menu:** Features categorized knowledge resources, with an improved display order for easier navigation and access.

Available access application:
https://play.google.com/store/apps/details?id=com.ssoft.ews4thai&hl=th&gl=US

5) Application "Water4Thai" developed by the Office of the National Water and Flood Management Policy, Prime Minister's Office. This application delivers daily alerts on the water situation in various regions. It is particularly useful for monitoring water levels and understanding the daily risks associated with water management, such as potential floods or droughts. The app includes detailed reports on thunderstorms occurring in each province, weather conditions, rainfall amounts, water levels in rivers nationwide, and water levels in Bangkok's canals. The application also has a live CCTV feature to monitor the conditions of various watersheds, reports on the water storage levels of reservoirs, and provides information on tidal surges. This makes Water4Thai a comprehensive tool for anyone needing up-to-the-minute information on water and weather-related conditions across Thailand.

Available access application: https://apps.apple.com/th/app/water4thai/id548984244.

Furthermore, Thailand has also developed an early warning system through a website to provide advanced alerts for potential natural disasters, which follows:

1) The National Water and Climate Data Center (NWCDC), developed by HII and ONWR, is the consolidation of data from Thai meteorological and water-related authorities. Data from 42 related agencies in Thailand, including area-based, statistical forecasting, and research related to water management, are integrated to maximize mutual benefits in managing water resources, controlling all situations, issuing disaster warnings, and minimizing loss of life and property in a timely manner. Initiated by His Majesty King Bhumibol Adulyadej in 1996 and expanded over the years, the center consolidates data from multiple agencies, starting with five and growing to 42 by 2019. The system, initially developed to support the “Weather901” website used by the King, now encompasses comprehensive data sets for improved monitoring, analysis, and forecasting of water and climate conditions, significantly aiding in both routine and crisis water management (Figure 4-6).

Available access data: https://nationalthaiwater.onwr.go.th/

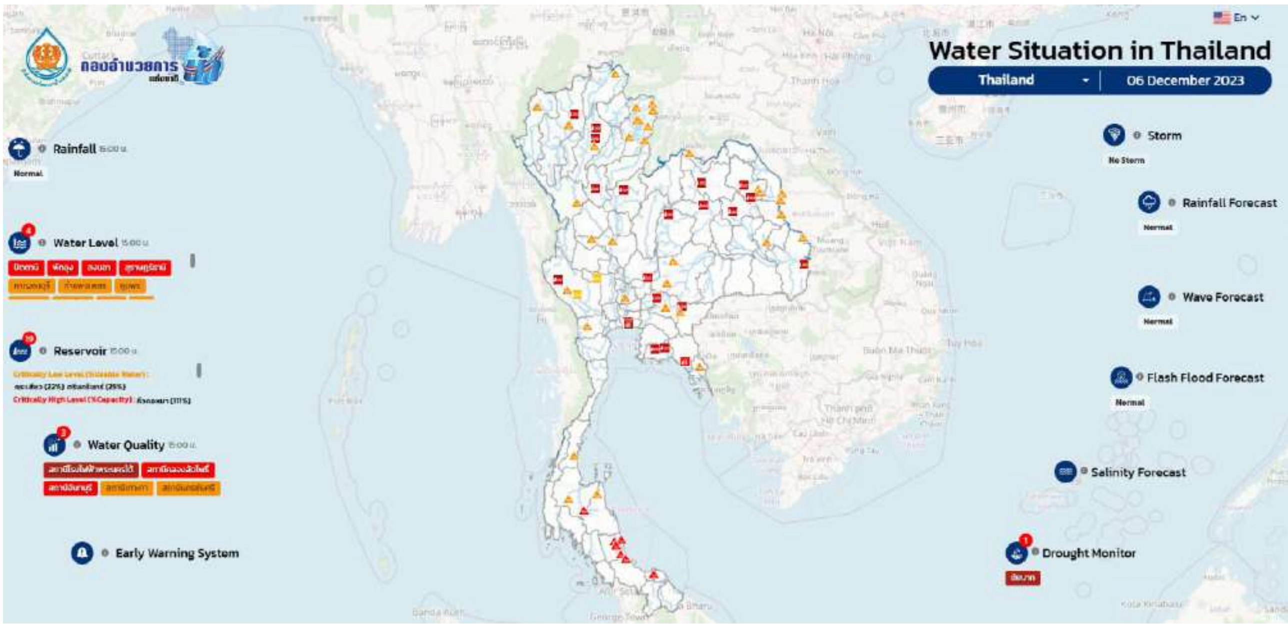

Figure 4-6: Details of NWCDC website

Source: Hydro – Informatics Institute (Public Organization) (2019)

2) Early Warning System (EWS) website - The website ews.dwr.go.th is an early warning system designed for areas at risk of flooding and landslides in hilly and foothill regions. Developed by DWR, it provides meteorological and hydrological data for monitoring and assessing water situations, as well as information on risks of potential flooding and landslides (Figure 4-7).

Available access data: https://ews.dwr.go.th/ews/index.php?language=en

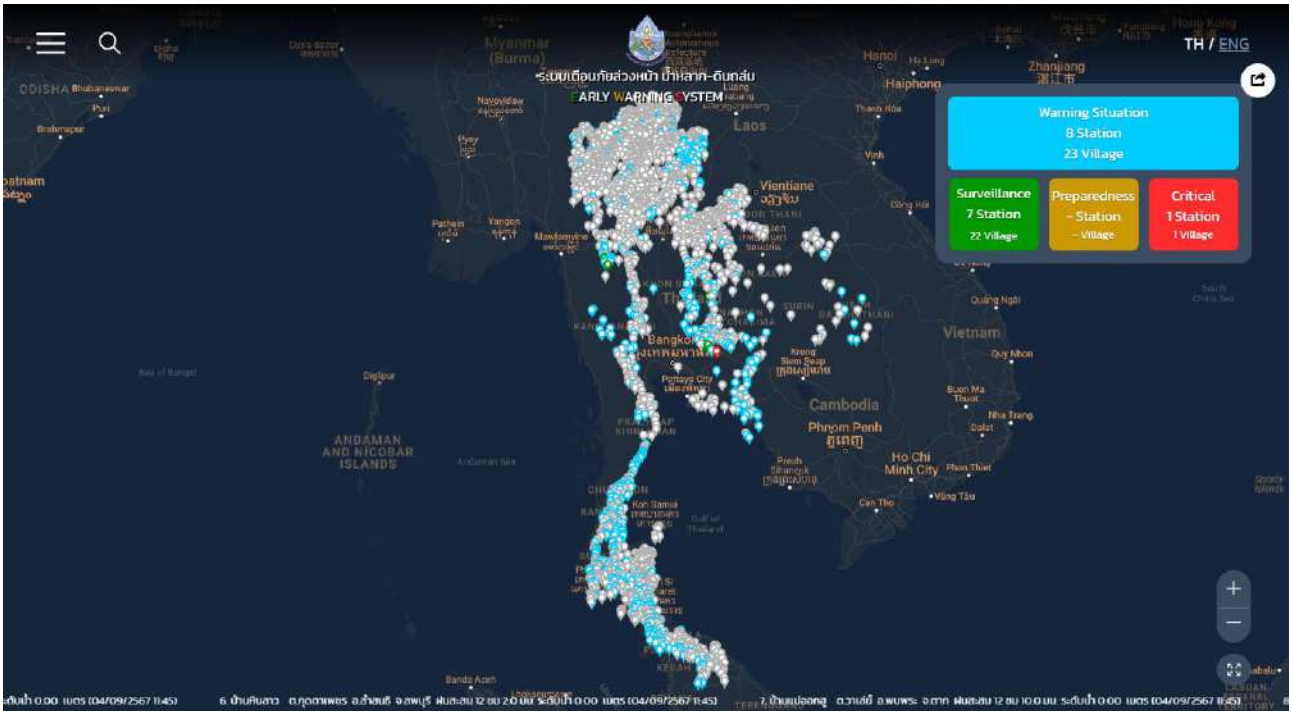

Figure 4-7: Details of EWS website

Source: Department of Water Resources (2024)

Additionally, Thailand is driving a future enhancement for early warning system by adopting the "Cell Broadcast Service" (CBS), set to launch in early 2025. This system is a collaboration between the MDES, the NBTC, the DDPM, and True Corporation. CBS will send emergency alerts to all mobile phones in affected areas, in five languages (Thai, English, Chinese, Japanese, and Russian), and is designed to enhance response to emergencies by providing timely alerts to both Thai citizens and international visitors. The system supports text, images, and sound alerts, and includes features like Text to Speech for visually impaired users. Alerts will be categorized into five levels, including national alerts, emergency alerts, amber alerts, public safety alerts, and test alerts. The full implementation is expected by early 2025, aiming to improve safety and efficiency in disaster response.

4.6.2 International Cooperation in Minimizing Damage and Loss

In 2020, The United States Agency for International Development (USAID) collaborated with the International Federation of Red Cross and Red Crescent Societies (IFRC) and the Thai Red Cross Society to develop the "Phonphai" application. The application is supported by a network of 19 agencies in Thailand, including the Thai Red Cross Society, DDPM, various government departments, and health organizations. The application was developed with the objective of “listening to the voice of the people”; it provides emergency assistance and enhanced public safety using IoT technology and GPS tracking. It allows users to send alerts, request help, and track the progress of assistance. The application offers a dashboard for overall situation reports, a map for locating services, a center for compiling assistance information, and a section for monitoring and managing aid. The system also includes features for tracking the status of aid requests and offers collaboration tools for various government agencies. The key features of this application are as follows

Dashboard: Summarized reports.

Assistance Requests: Submit help requests.

Help Center: Centralized support information.

Relief Items: Record of assistance provided.

Tracking Assistance: Monitor ongoing help efforts.

Online Map: Visualize locations of assistance needs.

Available access application:
https://play.google.com/store/apps/details?id=th.co.mm.phonphai&hl=th

In 2021, DDPM participated in a project to enhance the capabilities of Thailand's early warning system, known as the ThaiAWARE system. This project is a collaboration between DDPM and USAID. The initiative to develop this system was sparked by the 2004 tsunami in Thailand. In 2006, USAID, in collaboration with the National Disaster Warning Center, launched a project to enhance Thailand's and the region's capacity for hazard monitoring, early warning, and decision support (Regional and National Capacity Development for Hazard Monitoring, Early Warning, and Decision Support). This project received technical assistance from the Pacific Disaster Center (PDC), a unit under the University of Hawaii in the United States, and was initially named DisasterAWARE. In 2019, the program was renamed ThaiAWARE and was further developed to improve its capabilities, enabling the system to provide advance warnings to people in high-risk areas using technology and innovation for accurate and timely alerts (Figure 4-8).

Figure 4-8: Thailand participated in the project to enhance the capabilities of Thailand's early warning system.

Source: Department of Disaster Prevention and Mitigation (2021)

4.7 COOPERATION, GOOD PRACTICES, EXPERIENCES AND LESSONS LEARNED

Thailand has continuously worked to enhance its development strategies. The adoption of good practices, the strengthening of capacity building, and the accumulation of experience have all played critical roles in navigating the complex challenges that accompany adaptation progress. The following sections draw on case studies from across the country, incorporating cross cutting issues in the cases. The experiences highlighted here have been selected based on their demonstrated impact and potential for replication.

4.7.1 Water Resources Management Sector

Thailand's water resource management sector has demonstrated significant strides in adapting to climate change, particularly through community-driven initiatives.

The Ban Lim Thong Community Network, comprising nine sub-districts in Nang Rong District, Buriram Province, serves as a prime example. With support from the HII, the Utokapat Foundation under Royal Patronage of H.M. the King, and the RID, the community addressed water management issues by combining the traditional knowledge and experience of local elders with modern science and technology, following the royal initiative. This involved using satellite imagery, GPS, water flow analysis, water mapping, and collecting data on the area's elevation. The data was then linked to the actual terrain, and the process included fostering community participation in water resource management. These efforts created a model of sustainable success, enabling the community to manage its water resources independently. The community has implemented various projects aligned with the NAP. These efforts address critical aspects of water resources management, agriculture and food security, natural resources management, and human settlements and security (Figure 4-9).

Key initiatives include the construction of a 3.5 kilometer canal from the Mat canal in collaboration with the 8th Royal Irrigation Office, which facilitates water management by storing water for use during the dry season and by serving as a flood retention area during the rainy season. This initiative was further developed into a monkey cheek[1] reservoir (Wattanaprateep, 2016), connected to a canal that captures floodwater as a backup water source. The reservoir was excavated to varying depths to maintain a stable temperature conducive to the growth of aquatic life and to create a water circulation system within the reservoir. This water was then distributed to agricultural areas and stored in farm ponds through a connected pond system, ensuring a sufficient water supply for consumption, domestic use, and agriculture throughout the year.

The community has developed infrastructure by designing and inventing the 'Waterway Road', which is sloped to drain rainwater into the monkey cheek reservoir during the rainy season. They also developed a new water supply system, including the water distribution infrastructure and storage within the community. Additionally, they implemented a water treatment system by digging sedimentation ponds to trap soil sediment or debris carried by the water. The water is then

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[1] Monkey cheek is a water detention basin based on a flood-control concept suggested by His Majesty the King of Thailand, derives inspiration from the process in which monkeys store food in their cheeks and consume it incrementally.

channeled into the monkey cheek reservoir, where water hyacinths are cultivated to filter the water before it is released into the community's main water storage.

Additionally, the community has embraced EbA and NbS to improve soil quality, reduce water evaporation, and expand green spaces. The establishment of a disaster warning network through communication technologies further exemplifies the community's proactive approach to managing climate-related risks. This case study highlights how integrated water management, supported by local knowledge and modern technologies, can effectively mitigate the impacts of climate change, ensuring water security and agricultural sustainability for rural communities in Thailand.

(A) A pond with the planting of vetiver grass to prevent soil erosion

(B) A monkey cheek reservoir that serves as a sediment trap

(C) A water flow road with sloped areas designed to direct water into a monkey cheek reservoir

(D) A pond utilizing water hyacinth for filtration after passing through a sediment trap pond

Figure 4-9: Projects/activities conducted within the Ban Lim Thong Community Network

4.7.2 Agriculture and Food Security Sector

The Thai Rice Nationally Appropriate Mitigation Action (Thai-Rice NAMA) project is one example of good practices in agriculture adaptation. It reduces methane (CH_4) emissions and water use in rice production. The project uses four technologies: laser land leveling, alternate wetting and drying (AWD), site-specific nutrient management (SSNM), and straw and stubble management. AWD controls water levels in paddy fields to reduce water consumption and CH_4 emissions. This technique is vital in Thailand due to water shortages and extreme weather events. AWD helps lower GHG emissions and improves water efficiency in rice farming.

Moreover, the result of the project aims to develop a production process that emits low GHG, and increases productivity and sustainable income. This project can also build immunity and set guidelines for modern farmers to be able to adapt to the environment effectively. The adaptation benefit is the rice plants are strong and resistant to diseases and insects. This project is a successful model for new-generation rice farming that is environmentally friendly, passing on the idea to small-scale farmers covering all areas of Thailand with the measure of "3 Increases, 3 Reduces": increase rice productivity, increase rice quality, increase income, reduce production costs, reduce water resource consumption, reduce GHG emissions and global warming. The results of the operation during 2018-2021 found that more than 25,000 farmers have benefited from the project.

The Bang Rakam Model Project spans across two provinces, 5 districts, 20 sub-districts, and 93 villages in Phitsanulok and Sukhothai provinces. The districts involved include Phrom Phiram, Mueang Phitsanulok, Bang Rakam, and Wat Bot in Phitsanulok Province, as well as Kong Krailat District in Sukhothai Province. This project, supported by the Yom Nan Operation and Maintenance Office under RID, focuses on climate change adaptation in agriculture and food security, water resources management and natural resource management.

The areas in the Bang Rakam Model are low-lying plains located between the Yom River and the Nan River basin, which face flooding problems during the rainy season or flood season. This causes damage to agricultural products, particularly rice, cultivated in the area. During the dry season, the area also suffers from drought, which similarly affects the rice crops.

Key initiatives include promoting climate-smart agriculture (CSA) practices, improving water management systems in flood and drought-prone agricultural areas, and integrating natural resource management in terms of wetland management. This involves developing the rice cultivation areas of local farmers into man-made wetlands to serve as flood retention areas during the flood season. Farmers in the flood-prone areas have adjusted their crop cultivation to avoid damage during the rainy season by planting rice twice a year (first during December to March and again from April to July). They leave the fields fallow from August to November to act as natural flood retention areas. Additionally, the project integrates aquaculture as a supplementary livelihood, providing farmers with additional income during the flood season.

The project also emphasizes building agricultural networks to enhance climate resilience, raising awareness among farmers about the impacts of climate change, and promoting sustainable water resource management. Educational activities, community forums, and knowledge sharing through modern communication tools like using LINE application strengthen community resilience, making the Bang Rakam Model a sustainable model for agriculture and food security in the face of climate change (Figure 4-10).

(A) The farmland of farmers in the target area under the project

(B) Bang Kaeo Water Gate

(C) Farmers can begin cultivating off-season rice after the water level has receded and returned to normal conditions *

Figure 4-10: Projects/activities conducted within the Bang Rakam Model

Note: *Photo from the 2017 Bang Rakam Project Report, prepared by the Yom Nan Operation and Maintenance Office under the RID

4.7.3 Tourism Sector

Koh Mak Island, a renowned natural marine tourism destination in Thailand, has been significantly impacted by climate change. The island has faced several challenges, including rising temperatures and sea levels, which have led to coral bleaching and the death of marine life such as giant clams and seagrass. This has disrupted the local marine ecosystem, resulting in the disappearance of species like the hawksbill turtle, dugong, and whale. Additionally, coastal erosion due to stronger winds and waves has damaged homes, while unpredictable weather patterns and natural disasters have further harmed the local community.

In response to these challenges, Koh Mak has implemented various adaptation measures to reduce potential damage, with collaboration from the Koh Mak Subdistrict Administrative Organization, the DASTA, and the Koh Mak Coral Conservation group. These efforts align with the NAP, focusing on sustainable tourism practices by controlling the number of tourists on Koh Mak through the management of ferry services and hotel accommodations.

Measures include promoting waste separation among tourists, encouraging volunteer activities such as the Trash Hero cleanup project, conducting coral planting activities through diving, kayaking, and supporting cycling and the use of electric vehicles on the island. They also developed water reserves to serve during drought conditions and established Koh Mak Coral Conservation Group to protect and restore marine resources. One of the initiatives involves using sunshade nets to lower seawater temperatures in coral areas and planting coral seedlings using PVC frame structures. In the future, seagrass will be nursed in greenhouse systems (Aquarium).

Additionally, the Koh Mak Subdistrict Administrative Organization has developed a Disaster Prevention and Mitigation Action Plan (2022-2027), which includes strategies to reduce disaster risks, integrate emergency management, enhance sustainable recovery efficiency, promote international partnerships in disaster risk management, and improve disaster management systems and innovation development.

Local businesses have also adapted their operations in response to climate change. For example, hotels have switched to using glass bottles instead of plastic, encouraged tourists to reduce linen and towel changes to save energy and detergent, and planted beach morning glory along the shoreline to prevent coastal erosion. This helps reduce damage to hotel structures while increasing green spaces and enhancing the hotel's aesthetic appeal (Figure 4-11).

(A) The use of glass bottles instead of plastic bottles in hotels

(B) Planting beach morning glory to reduce coastal erosion around the hotel

(C) The use of electric vehicles by the Koh Mak Subdistrict Administrative Organization

(D) Coral cultivated on frames made from PVC pipes *

(E) Surveying the restored and replanted corals in the sea *

(F) Fieldwork to return the cultivated corals back into the sea *

(G) Promoting tourism activities through coral planting *

(H) Participating in coral planting activities to restore marine natural resources *

Figure 4-11: Projects/activities conducted within the Koh Mak

Note: * Photo from Koh Mak Coral Conservation Group

4.7.4 Natural Resources Management Sector

In the natural resources management sector, significant efforts are being made to address the challenges faced in **the Doi Chiang Dao Biosphere Reserve**, which spans an area of 52,100 ha across 16 villages in Chiang Mai province.

Due to activities undertaken by local villagers and indigenous ethnic groups in the Doi Chiang Dao area, such as logging in forested headwater areas for planting crops like corn and cabbage on steep slopes, significant environmental issues have arisen. These practices lead to the burning of agricultural residues after harvest and the use of pesticides, resulting in chemical contamination of water sources. Additionally, encroachment on forest areas for cultivation and hunting has led to conflicts between wildlife officials and locals over resource usage. The ongoing changes in climate further exacerbate these problems. The impacts on Doi Chiang Dao include:

- Soil erosion in headwater areas.
- Increased flooding due to the conversion of forested areas to agricultural land.
- Imbalance in biodiversity as certain species, particularly alpine plant communities and wildlife like the endangered sambar deer, begin to disappear.
- Migration of species such as birds and amphibians due to habitat changes.
- Reduced moisture retention in the limestone mountain environment, leading to increased aridity.
- Variability in natural phenomena (e.g., El Niño and La Niña events), affecting temperature, seasons, and water management within the area.
- Increased risk of wildfires and challenges to community livelihoods.

To combat these issues, the management strategy in the Chiang Dao area focuses on three main areas: conservation, development, and knowledge dissemination. The conservation efforts aim to protect biodiversity and the natural ecosystem by implementing the framework of the biosphere reserve. In terms of development, an inclusive economic model, known as the BCG Model, is promoted to ensure sustainable practices that balance ecological integrity with community needs. Furthermore, the initiative emphasizes enhancing local knowledge through education, research, and training to adapt to environmental changes, aiming to improve both natural resource management and the well-being of local communities. Collaboration among various agencies, including the DNP and local governments agencies, and local communities has been pivotal in executing integrated activities that align with the NAP. By focusing on ecosystem preservation, sustainable agroforestry, and community engagement, the Chiang Dao Wildlife Sanctuary exemplifies a holistic approach to natural resource management that seeks to balance ecological sustainability with the livelihoods of local communities (Figure 4-12).

Agencies operating in the Doi Chiang Dao area have implemented various integrated activities that align with the national climate change adaptation plan, focusing on ecosystem conservation, sustainable agriculture, and community involvement. These efforts serve as an exemplary model of holistic natural resource management that maintains ecological sustainability while supporting the livelihoods of local communities. Key actions in the area include:

- **Conservation and Biodiversity Preservation:** Biodiversity Conservation and Ecosystem Restoration: Initiatives to protect and restore biodiversity include promoting the planting of buffer forests, community reforestation using local plant species, and the annual restoration of degraded forests.
- **Support for Sustainable Agroforestry:** Transition to Diverse Farming Systems: The area supports local farmers in shifting from monoculture crops to diverse and sustainable agricultural practices, which improves soil health and reduces reliance on chemicals, thereby minimizing pollution risks.
- **Research and Monitoring:** Wildlife and Plant Community Studies: Research includes studying protected wildlife and plant communities, especially the unique alpine plant communities found only in Thailand. The development of databases on wildlife biodiversity in the Doi Chiang Dao Biosphere Reserve informs urgent management plans and assesses climate change impacts on wildlife using amphibians as indicators.
- **Community Cooperation:** Community Networks and Patrols: A network of 31 local communities has been established to conduct patrols and monitor hotspots. Collaboration with local government agencies involves using communication systems like LINE and radios for hotspot alerts.
- **Education and Vocational Training:** Training programs help former hunters and poachers transition to roles as tour guides, enhancing community involvement in conservation and providing alternative livelihoods.
- **Ecosystem Service Payments:** The PES mechanism is integrated to support conservation efforts and provide financial incentives for preserving ecosystem services.

(A) Forest Garden Maintenance through Rattan Planting *

(B) Planting Vetiver Grass to Prevent Soil Erosion in Watershed Areas *

(C) Building Check Dams in Watershed Areas *

(D) Implementing Agroforestry Systems

(E) Eco-Tourism and Agricultural Product Shops in Local Communities

(F) Temperature, Humidity, Wind Speed, and Rainfall Measurement System at the Watershed Management Unit of Khun Kong

(G) Water Level and Quantity Monitoring Station at the Watershed Management Unit of Khun Kong

(H) Propagation of Plant Seedlings for Distribution to Farmers

(I) Training for Guides and Porters **

(J) Study of the Wildlife Biodiversity Database in the Doi Chiang Dao Biosphere Reserve (Large-Eared Crowned Bat)***

Figure 4-12: Projects/activities conducted within the Doi Chiang Dao Biosphere Reserve

Note: Photo from * The Watershed Management Unit of Mae Ta Man,
** Doi Chiang Dao Biosphere Reserve,
*** Doi Chiangdao Wildlife.

4.7.5 Human Settlements and Security Sector

The Nonthaburi Municipality's Climate Change Adaptation Action Plan is supported by the European Union through the GCoM Asia project, which aims to engage and train cities in Southeast Asia, South Asia, and East Asia to reduce GHG emissions and achieve local targets, as well as NDCs, through the development of Climate Action Plans (CAP). Nonthaburi Municipality is one of four target municipalities in Thailand. The objectives are:

1) To assess the city's GHG emissions within its jurisdiction and support the city in setting emission reduction targets.

2) To analyze appropriate GHG reduction measures suited to the city's context.

3) To develop the city's CAP.

4) To formulate policy recommendations to enhance the effectiveness of the city's Climate Action Plan in achieving the set targets.

The Climate Action Plan of Nonthaburi Municipality includes both GHG reduction initiatives and climate change adaptation actions. The adaptation actions include seven specific activities:

1) Promoting the installation of household waste treatment systems.

2) Organizing a "Clean Canals and Clear Water for Disaster Reduction" contest.

3) Surveying and collecting data on high-rise buildings and housing estates to ensure compliance with legal requirements for open spaces and green areas.

4) Increasing green spaces and permeable areas in communities affected by the 2021 floods.

5) Developing community environmental networks that are climate friendly.

6) Providing appropriate training and welfare for municipal staff and employees working outdoors.

7) Educating village health volunteers and caretakers on caring for vulnerable groups to mitigate the risk of heat stroke.

Rewadee Community is an exemplary community that has implemented activities aligned with the Nonthaburi Municipality's Climate Change Action Plan. The community has transformed part of its land into green spaces, planting various types of trees and plants that provide shade and are also edible. These green areas are used for exercise, community activities, and events for both residents and neighboring communities. Additionally, they participated in the "Clean Canals and Clear Water for Disaster Reduction" contest, which is one of the activities under the municipality's action plan to address the impacts of climate change. The community has continuously monitored, evaluated, and actively implemented these initiatives, ultimately winning the award. They used the prize money as a budget to further their efforts in preventing and adapting the impacts of climate change within the community.

Also, the community shares knowledge related to climate change including both GHG reduction and climate adaptation such as they have implemented waste segregation before disposal for more efficient waste management. This waste can be composted into organic fertilizer to nourish and maintain the community's green areas.

Rewadee Community is an example of success in applying the action plan, based on collaboration with Nonthaburi Municipality, that can effectively mitigate the impacts of climate change, ensuring human settlements and security for other communities in Thailand (Figure 4-13).

(A) Green Globe Learning Center, Rewadee Community, Nonthaburi Municipality

(B) Pond and Green Spaces in Rewadee Community

(C) Trees and Plants in the Area

(D) Compost Production

(E) Solar Energy Applications

(F) Informational Flyer for the Canal Area Used for the "Beautiful Canal, Clear Water, Reducing Community Disasters" Contest

(G) Community Canals

(H) Oxygen Aerator for Canals

Figure 4-13: Projects/Activities Implemented within Rewadee Community, a Model Community Operating under the Nonthaburi Municipality's Climate Change Adaptation Action Plan

4.7.6 Public Health Sector

An example of good practice in the public health sector is **the Mae Na Subdistrict Municipality in Chiang Dao District, Chiang Mai Province**. Due to the geographical characteristics of Mae Na, which is a basin surrounded by mountains, during the dry season the air becomes dry and high pressure creates a closed atmospheric condition. This results in forest fires caused by agricultural practices or encroachment, including burning from neighboring countries and the effects of climate change leading to drier air, making fires more likely and harder to extinguish. Consequently, residents of Mae Na experience significant impacts from accumulated smog, more so than flat areas where air circulation is easier. Additionally, recent urbanization and construction materials that retain heat have exacerbated the issue, making the air in the municipality feel hotter. There has also been an increase in respiratory diseases and the spread of infectious diseases such as chickenpox and influenza. Furthermore, agricultural productivity, including fruits and vegetables like longan, mango, garlic, and chili, has decreased, directly affecting community health and nutrition. While the heat impacts some tourism activities negatively, it also creates positive effects in certain areas, such as cooler tourist spots along the Ping River and in the high mountains.

However, the Mae Na Subdistrict Municipality has recognized the problems faced by the community and has prioritized addressing them by collaborating with the Regional Health Promotion Center 1, Sub-district Health Promoting Hospital, village health volunteers, village headmen, and local residents to manage environmental health issues. These efforts include:

- **Capacity Building for Caregivers / Care Managers**: Training village health volunteers to care for vulnerable groups such as bedridden patients and those with respiratory conditions.
- **Development of an Automated Dust Monitoring System (PODD)**: This system reports PM2.5 dust levels, provides warnings and guidelines for village headmen, municipalities, health offices, and schools. It also monitors air pollution-related health issues to track the situation and ensure access to services for populations at risk.

- **Creation of "Dust-Free Rooms"**: Developing a platform for dust-free rooms in public health facilities, child development centers, elderly care facilities, and commercial establishments to allow the public to access services during high dust periods.
- **Expansion of Dust Nets**: Installing nylon or cotton nets combined with air purifiers for vulnerable groups, such as bedridden patients and those with respiratory conditions, to reduce and alleviate the health impacts of air pollution.
- **Strengthening Community Resilience**: Building community capacity to manage health risks from air pollution, including surveillance, warnings, health impact prevention, and maintaining a safe environment in collaboration with local networks.
- **Installation of Dust Monitoring Devices**: Implementing "Dustboy" devices to report dust levels and temperature. Additionally, the community and volunteers have established fire observation points and use the LINE app to communicate and alert residents about fire hotspots and forest fires, enabling timely response to manage the situation.

These activities also foster community participation in environmental management, strengthening community relationships and ensuring effective implementation of policies and solutions. They support sustainable livelihoods and are aligned with the National Climate Change Adaptation Plan in the public health sector and other related sectors (Figure 4-14).

(A) "Dust Net Project" to Mitigate the Impact of Air Pollution *

(B) Early warning and Communication to Address Air Pollution Issues *

(C) Constructing Check Dams **

(D) "Heun Na Pho Project: Self-Sufficient Living" **

(E) Constructing Bamboo Rafts for Ecotourism **

(F) Making Leaf Plates by Tourist Groups **

(G) Communities with Ecological Lifestyles (Eco-villages)

(I) Making Sticky Rice in Bamboo **

(J) Crafting Bamboo Products from Natural Bamboo **

Figure 4-14: Projects/activities conducted within the Mae Na Subdistrict Municipality in Chiang Dao District, Chiang Mai Province

Note: Photo from *Regional Health Promotion Center 1 Chiang Mai

**Mae Na Subdistrict Municipality

Chapter V

INFORMATION ON FINANCIAL, TECHNOLOGY DEVELOPMENT AND TRANSFER AND CAPACITY-BUILDING SUPPORT NEEDED AND RECEIVED UNDER ARTICLES 9–11 OF THE PARIS AGREEMENT

CHAPTER 5
INFORMATION ON FINANCIAL, TECHNOLOGY DEVELOPMENT AND TRANSFER AND CAPACITY-BUILDING SUPPORT NEEDED AND RECEIVED UNDER ARTICLES 9–11 OF THE PARIS AGREEMENT

Thailand has received support from various international partners to facilitate climate actions in mitigation, adaptation, and cross-cutting, including other facilities supporting activities under the Paris Agreement such as manipulation of emission reduction targets in NDC and LT-LEDS as well as preparation of the National Communications, Biennial Updated Reports and First Biennial Transparency Report. Moreover, Thailand still needs more support for transformational changes leading to tangible implementation in combating climate change and achieving the targets of Paris Agreement.

5.1 UNDERLYING ASSUMPTIONS, DEFINITIONS AND METHODOLOGIES

"Baht" is the currency of Thailand, with the currency code "THB" and the symbol "฿". As of 2022, Thailand annual exchange rate against the United States dollar (USD) averaged 35.06 (THB/USD), the Sterling (GBP) averaged 43.26 (THB/GBP) and the EURO averaged 36.87 (THB/EUR) (NSO, 2023). Thailand received support in both bilateral and multilateral channels disbursed as grants from many sources such as the Global Environment Facility (GEF), the Green Climate Fund (GCF). During the period of 2022-2024, Thailand has received funding for 66 projects, with a total amount approximately 38,668.47 MTHB or 1,102.92 MUSD. The funding has been allocated to 40 mitigation projects (23,505.97 MTHB or 670.45 MUSD), 8 adaptation projects (3,230.03 MTHB or 92.13 MUSD), and 18 cross-cutting projects (11,932.46 MTHB or 340.34 MUSD). Details of support needed and received for each project as well as the project status are described in the next two sections.

5.2 INFORMATION ON FINANCIAL, TECHNOLOGY DEVELOPMENT AND TRANSFER AND TRANSPARENCY-RELATED ACTIVITIES AND CAPACITY-BUILDING SUPPORT NEEDED UNDER ARTICLE 9–11 OF THE PARIS AGREEMENT

Thailand, as a developing country, has received support and international cooperation in terms of financial, technology development and transfer and capacity-building. The support has been deployed to improve the quality of the national inventory to be consistent with the framework of Transparency, Accuracy, Completeness, Consistency, and Comparability (TACCC) and to implement activities relevant to mitigation, adaptation and cross-cutting in all sectors in order to achieve emission reduction goals in both the NDC and LT-LEDS.

In addition, Thailand is developing its next NDC with a more ambitious emissions reduction target in alignment with the 1.5 degrees pathway to be a part of its commitment to the Paris Agreement. Its reduction target is to be revised from the baseline and move toward undertaking an absolute economy-wide reduction target, which correlates to national emission levels at specific years.

However, Thailand still faces limitations and barriers in many key perspectives, for example, improvement of the quality of national statistics to achieve greater accuracy and completeness of their national GHG inventory, understanding on methodologies of GHG emissions as well as reductions among key stakeholders, mitigation technologies for supporting its NDC emission reduction target, specifically in hard abated sectors, and strengthening of people knowledge on adaptation and climate change impacts. Our support needed can be summarized by sectors as detailed below (see Table 5-1).

Energy

According to supporting accuracy of emission reduction estimation as well as achievement of NDC and LT-LEDS, significant improvements are in two perspectives: national GHG inventory and mitigation technologies. For national GHG inventory, support in terms of finance and transparency-related activities and capacity-building are needed. Thailand needs, immediately, to be assisted in:

- improving country-specific emission factors, especially for key categories
- improving collection of national statistics on fuel consumption of international aviation
- understanding methodologies of GHG emissions reductions from measures

In the mitigation perspective, all in terms of finance, technological development and transfer and capacity-building in specific technology are required. Thailand urgently needs:

- in near-term, support for the energy transition towards renewable sources focusing on renewable energy technologies (such as solar and wind); assistance in advanced Energy Storage Systems (EES) and demand-side management; development of Electric Vehicles (EV), batteries, and infrastructure; and increasing grid modernization, smart energy management, and Independent Power Supply (IPS)
- in medium- to long-terms, support to enhance the potential use of carbon capture, carbon utilization in permanent materials and carbon storage technologies, and Bioenergy with Carbon Capture and Storage (BECCS), hydrogen technology; especially for green or cleaner hydrogen, bio-hydrogenated diesel, and other advanced low carbon technologies in hard abated sectors.

Industrial Processes and Product Use (IPPU)

At present, emissions from non-metallic industries, especially for cement production, are a major contribution in the IPPU sector, and there is significant emission reduction potential in accordance with Thailand's NDC and LT-LEDS. However, Thailand has endeavored to mitigate emissions in other industries and improve its GHG emission estimation in this sector, covering all industrial types, for more accuracy, completeness and transparency of its national inventory. Therefore, in order to support accurate emission reduction estimation of its NDC, Thailand urgently needs:

- in near- to medium- terms, improvement of country-specific emission factors is important to enhance GHG emissions estimation using Tier 2 approach. Besides that, due to limitations of technical information such as initial charge and lifetime of equipment, improvement of activity data collection processes is required, especially for activity related to F-gases emissions,

Agriculture

To achieve more accurate GHG estimations using a higher tier, the specific data need to be collected and/or revised, including livestock characteristics and fractions of manure in management systems. In addition, determination of more appropriate methods to estimate areas burnt in croplands by using satellite images, revision of crop residues fractions, assortment of lime application to croplands from private sector, determination of fertilizer application rates of major crops using a bottom-up approach, development of country-specific emission factors for agricultural soils and rice cultivation with water management (e.g., alternative wetting and drying) urgently need to be implement.

Moreover, to support the NDC mitigation target, GHG reduction technologies are also required, especially for methane reduction in rice cultivation in near-term and soil and manure management in mid- and long-term. However, other advanced GHG emission reduction technologies apart from the above to reduce methane emissions in agricultural sector are also required.

Land Use, Land-Use Change, and Forestry (LULUCF)

Data gaps between public and private data are the main issue on forest plantation areas. Activity data for biomass burning in forest land reported by various departments remains unclear in terms of burned areas and/or land categories. Therefore, with the aim at improvement of GHG estimation accuracy, support on remote sensing-based monitoring of land use and land cover are needed to classify types of natural forests and forest plantations, monitor their changes, and detect forest area burning.

As with other sectors, Thailand has intended to enhance its National GHG Inventory. Support on improvement of specific-emission factors as well as relevant parameters is urgently needed in many parts under the LULUCF sector, which is the main removal area.

Waste

Although Thailand has some specific-country parameters, such as solid waste composition and annual per capita protein consumption, to estimate the emissions in the waste sector, they are out of date and do not reflect reality. In addition, many parameters, i.e. industrial production, wastewater generated, Chemical Oxygen Demand (COD), degree of utilization of treatment discharge pathways or systems, etc., need to be investigated and identified for specific-country parameters in order to improve its emission estimation.

Besides the agricultural sector, the waste sector has been the main contributor of methane emissions. Therefore, both financial and technological support on waste and wastewater management as well as all GHG emission reduction technologies are urgently needed.

Table 5-1: Information on support needed for national inventory improvement and mitigation activities in Thailand

Sectors	Titles (Activity/programme/ project)	Expected timeframe	Type of supports needed			
			FC	TT	CB	TRA
Energy	Improving country-specific emission factors	2025–2027	X		X	X
	Improving collection of national statistics on fuel consumption of international aviation	2025–2026	X		X	X
	Understanding methodologies of GHG emissions reductions from measures	2025–2028	X		X	X
	Supporting low carbon technologies for the energy transition	2025–2035	X	X	X	
IPPU	Estimating GHG emissions using Tier 2 approach	2025–2026			X	
	Improving country-specific emission factors	2025–2028	X	X	X	
	Improving collection of national statistics on F-gases consumption	2025–2027	X	X		X
Agriculture	Improving collection of national statistics for Agriculture sector	2025–2027	X	X		X
	Improving country-specific emission factors	2025–2028	X	X		
	Improving the QA/QC procedure and uncertainty analysis	2025–2026	X	X		X
	Strengthening institutions' capacity in data collection, quality control of data, and enhancing mitigation measures	2025–2026	X	X		X
	Supporting GHG reduction technologies in agriculture sector	2025–2035	X	X		
LULUCF	Remote sensing-based monitoring of land use and land cover	2025–2028	X	X	X	X
	Improving collection of national statistics on cropland and forest land	2025–2027	X	X	X	X
	Improving country-specific emission factors	2025–2028	X		X	X
Waste	Improving data collection systems and the creation of a centralized database	2025–2027	X	X	X	X
	Improving country-specific emission factors	2025–2028	X		X	
	Improving QA/QC system	2025–2026				X
	Supporting GHG reduction technologies in waste sector	2025–2035	X	X		

Remarks: "FC" represents support on finance.
"TT" represents support on technology development and transfer.
"CB" represents support on capacity-building.
"TRA" represents support on transparency-related activities.

Adaptation and cross-cutting sectors

Thailand is highly vulnerable to climate change impacts. According to the Global Climate Risk Index 2021, Thailand was ranked the ninth most affected country in terms of human impacts and direct economic losses from weather-related loss events during 2000-2019. Aiming to increase adaptive capacity and climate resilience, Thailand has formulated the National Adaptation Plan (NAP) to be an implementation framework to integrate climate change adaptation into the sectoral and local strategic plans, covering six priority sectors, including water resources management, agriculture and food security, tourism, public health, natural resources management, and human settlements and security.

The provision of funding for activities related to climate change adaptation aims to reduce risks, impacts, and vulnerabilities caused by climate change, as well as to capitalize on potential projects. The mechanisms involved include capacity building, technology transfer, and economic development to transform the country into a low-carbon society capable of coping with climate change, moving towards sustainable development.

Because securing financing is crucial for the implementation of adaptation goals and strategies in Thailand, initiatives have also been taken to develop the climate finance landscape in the country. For example, the "Accelerating Climate Finance in Thailand" project, launched by the Asian Development Bank (ADB) and Thailand's Ministry of Natural Resources and Environment on June 24-28, 2024 (Asian Development Bank, 2024), plays a critical role in Thailand's resilience and adaptation to climate change by:

1) Increasing financial resources from public, private, and capital markets.
2) Developing new financial tools like national derisking mechanisms and sustainability-linked bonds.
3) Creating strategies and pilot projects for electric mobility, resilient cities, and biodiversity.
4) Building capacity in innovative climate finance.
5) Developing attractive project models for private investors to boost participation.

The limitations and challenges mentioned above are major obstacles to effective climate change adaptation action in each sector, it is now crucial to focus on the support mechanisms that can overcome these obstacles. To ensure that adaptation actions are both impactful and sustainable, comprehensive support is necessary across various agencies and issues.

Table 5-2 explores the types of support needed to effectively address these challenges and enable successful adaptation efforts for each sector.

Table 5-2: Information on support needed for adaptation and cross-cutting sectors in Thailand

Sectors	Suggestions
Water resources management	- **Develop Collaborative Plans and Clear Communication:** creating coordinated plans, maintaining open channels of communication between agencies, defining guidelines for collaboration, and putting in place accurate processes to track progress. - **Clarify Roles and Integration:** The focal agencies should discuss and define roles, operational frameworks, and the integration of cooperation between agencies to clarify roles, duties, and responsibilities. - **Develop Analytical Tools and Frameworks:** Develop tools or frameworks to support adaptation and long-term planning, including promoting research and study on key baseline data, and utilizing technologies for analyzing climate and water data. - **Conduct Training and Build Capacity:** Provide training and capacity-building for responsible agencies, including local level, and develop a network of experts who can provide suggestions and support for water resource management at various levels. - **Pre-implementation Data Collection Requirements:** Mandate the collection of data prior to implementation as part of the technical requirements for all projects to assess impacts, improve future projects, and develop practical and effective data collection tools. - **Seek Additional Budget Support:** Additional budget support from the government or foreign countries should be provided to enhance O&M capabilities.

Table 5-2: Information on support needed for adaptation and cross-cutting sectors in Thailand (Cont'd)

Sectors	Suggestions
Agriculture and food security	- **Conduct Training and Knowledge-Building Activities for Farmers:** Provide training and activities to enhance farmers' knowledge on climate adaptation, focusing on practical techniques and methods. Encourage farmers to use technology and provide information on tools that facilitate adjustment. - **Promote Collaboration with the Private Sector and International Organizations:** Encourage cooperation with the private sector and international organizations in securing financial support, including the establishment of a climate change fund that focuses on helping farmers with adaptation, with an emphasis on providing friendly and appropriate conditions for small-scale farmers. - **Expand Financial Support for Agriculture and Climate Change Research:** Additional funding should be allocated for research on agriculture and climate change. - **Establish Mechanisms for Research Coordination:** Develop procedures to support and coordinate between research agencies to increase the efficiency and feasibility of requesting research funding from various sources, both domestically and internationally. - **Support Field Research related to Farmer's Adaptation:** Encourage field research on farmers' adaptability, involving communities in planning and implementation, so that research results can be applied in the area.
Tourism	- **Develop and Integrate Tourism with Climate Change Awareness:** Promote awareness among tourists and business owners about the impacts of climate change through tourism, leading to tangible actions. - **Create Awareness Campaigns:** Develop communication campaigns to raise awareness among domestic and international tourists about the impacts of climate change. Utilize social media, travel websites, and various digital platforms to disseminate information, and collaborate with relevant organizations to expand the reach of the information. - **Promote Funding for Adaptation Activities:** Advocate for increased funding from government agencies and establish a fund to support adaptation activities. This should include monitoring changes, planning for resilience, and conserving both man-made and natural tourist areas effectively. - **Develop Climate Impact Monitoring Systems:** Create monitoring systems to assess the effects of climate change on natural tourist attractions, which will be used to improve and create future adaptation measures. - **Establish Climate-Specific Insurance Systems:** Develop insurance systems tailored to the tourism sector that cover risks from climate-related disasters. - **Promote Measures that Reduce GHG Emissions:** Encourage measures that both reduce GHG emissions and facilitate adaptation, such as promoting renewable energy use in hotels and tourist sites or developing sustainable tourism practices that minimize environmental impact.
Public health	- **Develop Training Programs for Medical Personnel:** Create training programs for healthcare professionals on the relationship between climate change and public health, focusing on potential impacts. - **Integrate Climate Change Knowledge into Medical Education:** Incorporate climate change and its health impacts into medical education curriculum to ensure new healthcare professionals are well-equipped to handle potential effects. - **Establish a Central Database:** Create a central database that compiles data on the impacts of climate change on public health. This data should be gathered from various sources such as hospitals, public health agencies, and research studies to support planning and decision-making. - **Develop Data Integration Systems:** Build systems to connect the database with relevant agencies, such as the Department of Disease Control or the Department of Public Health, to ensure comprehensive and internationally usable data. - **Promote Research on Climate-Health Links:** Support and promote research that investigates the connections between climate change and various diseases. - **Foster International Collaboration:** Encourage international cooperation in research and data sharing regarding climate impacts and related diseases to enhance effectiveness in prevention and adaptation.

Table 5-2: Information on support needed for adaptation and cross-cutting sectors in Thailand (Cont'd)

Sectors	Suggestions
Natural resource management	- **Promote and Support Research on Ecosystem Impacts:** The government should encourage and support research focusing on the impacts of climate change on terrestrial, marine, and coastal ecosystems to deepen understanding and apply findings in adaptation planning and implementation. - **Foster Collaboration Among Institutions:** Promote collaboration between educational institutions, government agencies, and international organizations for research and data sharing on ecosystems. - **Allocate Additional Resources to Local Agencies:** The government should consider allocating additional budget and resources to local agencies involved in natural resource management to enhance the effectiveness of adaptation measures. - **Implement Training Programs:** Develop training programs to enhance the knowledge and skills of local agency personnel, ensuring they are proficient in implementing effective measures for the protection and conservation of natural resources and ecosystems. - **Establish Coordination Mechanisms:** Set up a committee or central mechanism to coordinate adaptation measures among various agencies involved in natural resource management, facilitating efficient data collection and sharing. - **Develop an Online Platform:** Create an online platform for collecting and sharing adaptation project data from all relevant agencies within each sector, ensuring transparency and usefulness in planning and decision-making.
Human settlements and security	- **Develop Local Climate Data Systems:** Develop local climate data systems that can be used effectively for adaptation planning in individual communities and regions. - **Support Local Research and Surveys:** Support research and surveys at the local level to obtain detailed and accurate data for adaptation planning. - **Establish Dedicated Agencies or Groups:** Establish specific agencies or groups responsible for planning and implementing climate adaptation measures to ensure effective action and rapid response to situations. - **Promote Coordination and Collaboration:** Encourage coordination and collaboration among relevant agencies to ensure integrated adaptation planning and implementation. - **Enforce Building and Infrastructure Regulations:** Implement mandatory regulations or guidelines that require building designs, structures, and early warning systems to consider the impacts of climate change, such as designing buildings to withstand increased natural disasters. - **Incentivize Sustainable Design Practices:** Develop measures to promote and incentivize real estate developers and architects to adopt sustainable and climate-resilient design practices. - **Increase Access to Funding:** Publicize and enhance access to various funding sources, both domestic and international.

In conclusion, Thailand's adaptation challenges can be addressed by having a unified system and better budget management. A system connecting all related agencies with common databases, research information, and innovation platforms is essential. Networks of experts, financing plans, and a robust Monitoring and Evaluation (M&E) system are crucial. Strengthening capacity-building programs for government agencies is necessary to improve their skills in designing adaptation programs and integrating climate adaptation. Improved coordination among agencies will enhance synergy and resource use.

On the budget front, innovative financing methods, such as using fiscal and monetary instruments (e.g., taxes, bonds) and private financing schemes (e.g., crowdfunding), are needed to supplement the limited public budget. Strategic short, medium, and long-term financing plans should be developed to identify suitable funding sources and types for various interventions. Efficient use of the government budget should focus on investments that benefit multiple agencies, target vulnerable regions and sectors, introduce adaptable technologies, emphasize low-cost, high-impact adaptation measures, and generate scalable good practices and knowledge sharing. This comprehensive approach provides a good starting point in managing Thailand's adaptation challenges.

Furthermore, the following technical support may be needed in addressing Thailand's adaptation sector-specific and cross-cutting challenges:

1) Data System:
    - Nationwide Data Strengthening: Improve the data system for climate change adaptation across different spatial scales and sectors to ensure it is reliable, up-to-date, publicly available, and accessible by both national and sub-national agencies.
    - Data Provision and Utilization: Enhance the quality, availability, and management of climate and socio-economic data, and improve the capacity to interpret and analyze this data for planning, programming, and decision-making in key adaptation sectors.
2) M&E System:
    - National M&E System: Design and establish a national M&E system for climate change adaptation to ensure the long-term success and effectiveness of adaptation actions aligned with the NAP.
    - Challenges in M&E: Address challenges such as the long-time frames associated with climate change impacts and relevant adaptation outcomes; uncertainty in climate change magnitude and nature, particularly in the local level; and the need for a moving baseline for monitoring and comparing results because using static baseline conditions may be inadequate.
3) Financing Mechanisms:
    - Innovative Financing: Develop new financing mechanisms to address the current budget constraints, focusing on climate-resilient infrastructure that requires substantial upfront investment but offers long-term benefits.
    - Capacity Building: Enhance the capacities of finance and climate-related agencies to initiate sustainable financing measures, including leveraging international climate-related funds and private sector investment where feasible.

5.3 INFORMATION ON FINANCIAL, TECHNOLOGY DEVELOPMENT AND TRANSFER AND TRANSPARENCY-RELATED ACTIVITIES AND CAPACITY-BUILDING SUPPORT RECEIVED UNDER ARTICLE 9–11 OF THE PARIS AGREEMENT

Thailand has received support for national inventory improvement and mitigation activities as well as adaptation activities and cross-cutting sectors from various resources, which can be summarized as follows.

Support for national inventory improvement and mitigation activities

Project #1: Support to Global Covenant of Mayors for Climate and Energy (GCoM)

Project description:	Support to Global Covenant of Mayors for Climate and Energy (GCoM) in Asia aims to enhance and develop the capacity of GHG mitigation mechanisms, and climate finance assessment for Thai local organizations (20 municipalities)
Channel:	Multilateral
Amount received:	1,878,176.93 Baht / 53,570.36 USD
Timeframe of the project:	2022–2023
Status:	Received
Sector and subsector:	Multi-sector
Type of support:	Mitigation
Activity contributed to:	Capacity building
Status of project:	Complete

Project #2: GCF Readiness and Preparatory Support Programme: Developing GCF pipeline of projects from locally-driven climate actions

Project description:	The project is funded by GCF for the period of 24 months and focuses on the prioritization of scaling up climate change mitigation actions at local level through improved energy efficiency, renewable energy in households, and strengthened municipal wastewater management. There are 2 main objectives of this project (1) Enhancing capacity and knowledge of Local Government stakeholders on mainstreaming the prioritized climate actions into city development planning processes; and (2) Enhancing local government capacity on securing domestic sources of fund, in parallel with enhancing the local government skill on accessing international sources of fund by assisting them to develop the quality funding proposals, particularly to be in line with the Green Climate Fund (GCF) and other climate finance funds.
Channel:	Multilateral
Amount received:	12,249,965.00 Baht / 349,400.03 USD
Timeframe of the project:	2022–2025
Status:	Received
Sector and subsector:	Multi-sector
Type of support:	Mitigation
Activity contributed to:	Capacity building
Status of project:	Ongoing

Project #3: Introducing Measures, Pathways and Roadmaps for Optimizing Vehicle Efficiency and Electrification (IMPROVE)

Project description:	The objective of this project is to support the preparation of policies to promote energy efficiency for vehicles. Policies and regulations are being selected to be proposed as policies to promote the use of energy-efficient vehicles.
Channel:	Bilateral
Amount received:	147,480,000.00 Baht / 4,206,503.14 USD
Timeframe of the project:	2023-2026
Status:	Received
Sector and subsector:	Transport
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #4: Thai - German Cooperation on Energy Mobility and Climate (TGC – EMC)

Project description:	This project focuses on the transition of energy use to clean energy. DCCE is the main agency, working with 5 sectors: energy, transportation, agriculture, industry, and finance for climate change.
Channel:	Bilateral
Amount received:	718,965,000.00 Baht / 20,506,702.80 USD
Timeframe of the project:	2022-2027
Status:	Received
Sector and subsector:	Transport
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #5: Hydrogen Ramp - up Programme (H2Uppp)

Project description:	This project is to develop a green hydrogen market and Power to X in the energy, transport and industry sectors through supporting joint operations with the private sector and government policy.
Channel:	Bilateral
Amount received:	848,010,000 Baht / 24,187,393.04 USD
Timeframe of the project:	2023-2025
Status:	Received
Sector and subsector:	Transport
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #6: Strengthen Thailand's expertise to support long - term GHG mitigation planning in the transport sector

Project description:	This project is to support the revision and improvement of Thailand's NDC Action Plan 2021-2030 in the Transport Sector, in aligning with the 2nd Updated NDC target and the TH-LEDS.
Channel:	Bilateral
Amount received:	1,843,500.00 Baht / 52,581.29 USD
Timeframe of the project:	2022-2023
Status:	Received
Sector and subsector:	Transport
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Completed

Project #7: Supporting NDC Target through Incentivizing Use of Electric Vehicles

Project description:	This project is to support the achievement of Thailand's NDC and SDGs, focusing on promoting the use of various types of electric vehicles/low emission vehicles, including battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs), including personal cars, trucks, tricycles, and motorcycles.
Channel:	Bilateral
Amount received:	48,382,800.00 / 1,380,000.00 USD
Timeframe of the project:	2023-2024
Status:	Received
Sector and subsector:	Transport
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #8: United Kingdom Partnering for Accelerated Climate Transition (UK PACT)

Project description:	This project is to organize a workshop on "Congestion Charge & Low Emission Zone & Ultra Low Emission Zone" with Mr. Henry Cresser, an expert from Transport for London, as a speaker to present the measures for collecting road usage charges in dense traffic areas (Congestion Charge) in London and develop project proposals to assess greenhouse gas reduction in the transport sector from congestion charge.
Channel:	Bilateral
Amount received:	21,630,000.00 Baht / 616,942.38 USD / 500,000.00 GBP
Timeframe of the project:	2023
Status:	Received
Sector and subsector:	Transport
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Completed

Project #9: Accelerating the adoption and life cycle solutions to electric mobility in Thailand

Project description:	To mitigate greenhouse gas emissions from the transportation sector by addressing barriers to the adoption and scale-up of electric mobility in Thailand through enhancing policy and regulatory framework, technology demonstrations in Thailand's Eastern Economic Corridor, and capacity building and knowledge sharing.
Channel:	Multilateral
Amount received:	101,674,000.00 Baht / 2,900,000.00 USD
Timeframe of the project:	2024–2029
Status:	Received
Sector and subsector:	Energy sector
Type of support:	Mitigation
Activity contributed to:	Technology development and transfer
Status of project:	Ongoing

Project #10: Clean, Affordable, and Secure Energy for Southeast Asia: CASE

Project description:	Under the Office of Energy Policy and Planning, this project aims at supporting the national energy plan, such as researching and compiling academic data on the global energy situation and activities to promote energy transition to help reduce the impact of climate change, such as technical assistance and advice, sharing lessons learned from other countries in the region, etc.
Channel:	Multilateral
Amount received:	66,807,324.00 Baht / 1,905,514.09 USD
Timeframe of the project:	2020–2027
Status:	Received
Sector and subsector:	Transport sector
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #11: HCFCs Phase Out Management Plan Stage II (HPMP)

Project description:	(1) Air-conditioning maintenance and installation technician training project in collaboration with the Department of Skill Development and the Office of the Vocational Education Commission, with a total of 4,560 trainees, along with providing 4,560 sets of tools and equipment to support training. (2) Assistance for entrepreneurs in the spray foam industry to change the production process to use substances that do not destroy the ozone layer and have a low global warming potential.
Channel:	Multilateral
Amount received:	30,000,000 Baht / 855,675.98 USD
Timeframe of the project:	2020-2025
Status:	Received
Sector and subsector:	IPPU
Type of support:	Mitigation
Activity contributed to:	Capacity-building and Technology development and transfer
Status of project:	Ongoing

Project #12: Decarbonization of Cement and Concrete in Thailand (DCCT)

Project description:	(1) To study and develop recommendations on the policy framework and strategies for net zero greenhouse gas emissions; (2) To establish an Accelerated Innovation Promotion Programme; (3) To pilot the use of innovative carbon reduction technologies; (4) To study, develop and promote standards/guidelines related to low carbon cement and concrete products; (5) To develop an MRV system; (6) To conduct training and seminars; and (7) To exchange knowledge with other countries in line with South-South Cooperation.
Channel:	Multilateral
Amount received:	210,000,000.00 Baht / 5,989,731.89 USD
Timeframe of the project:	2024 - 2026
Status:	Received
Sector and subsector:	IPPU
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #13: Applications of Industry-urban Symbiosis and Green Chemistry for Low Emission and Persistent Organic Pollutants (POPs)-Free Industrial Development in Thailand

Project description:	The project will focus on the application of industry-urban symbiosis and green chemicals for low emission and persistent organic pollutants (POPs)-free industrial development in Thailand. The main objective is to reduce greenhouse gas emissions, as well as releases of persistent organic pollutants and other harmful chemicals from industries and urban centers through the application of industry-urban symbiosis and green chemistry technology.
Channel:	Bilateral
Amount received:	290,000,000.00 Baht / 8,271,534.51 USD
Timeframe of the project:	2020-2025
Status:	Received
Sector and subsector:	IPPU
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #14: Nitric Acid Climate Action Group (NACAG) in Thailand

Project description:	The objective of the project is to support the reduction of nitrous oxide (N_2O) from the production processes by providing: 1) policy and strategic consultation on nitrous oxide emission requirements, 2) technical support for reducing nitrous oxide, 3) financial support for Thailand's nitric acid industry, 4) capacity building to monitor and report nitrous oxide emissions and 5) support for reporting greenhouse gas emissions under the NDC
Channel:	Bilateral
Amount received:	1,870,304,490.00 Baht / 53,345,821.16 USD
Timeframe of the project:	2016 - 2025
Status:	Received
Sector and subsector:	IPPU
Type of support:	Mitigation
Activity contributed to:	Capacity building
Status of project:	Ongoing

Project #15: Thai Climate Initiative: ThaiCI

Project description:	To establish "ThaiCI" Fund for supporting mitigation, adaptation and capacity-building in 5 areas: biomass, renewable energy, transport, energy efficiency improvement and finance.
Channel:	Bilateral
Amount received:	162,228,000.00 Baht / 4,627,153.45 USD
Timeframe of the project:	
Status:	Received
Sector and subsector:	Mechanism Strengthening
Type of support:	Mitigation
Activity contributed to:	Financial support
Status of project:	Ongoing

Project #16: Tillage and Organic Fertilizer Production to Prevent Greenhouse Gas in the northern agricultural areas

Project description:	To transform into climate-friendly agricultural waste management which can reduce the burning of agricultural waste, reduce GHG emissions, and add organic matter to the soil to benefit plant growth.
Channel:	Bilateral
Amount received:	7,012,000.00 Baht / 200,000.00 USD
Timeframe of the project:	2021-2023
Status:	Received
Sector and subsector:	Agriculture
Type of support:	Mitigation
Activity contributed to:	Technology development and transfer
Status of project:	Completed

Project #17: Integrated Urban Climate Action for low carbon and resilient cities project (Urban Act)

Project description:	Integrated urban development project for low-carbon growth and resilient cities in 5 countries, including Thailand, India, the Philippines, China and Indonesia. It aims at 1) supporting adaptation plans in the transport sector, 2) supporting integration of climate change into transport planning in the city, 3) training in adaptation on transport infrastructure, 4) advertising on climate adaptation in transport sector, and 5) supporting drafting of concept notes for urban transport projects.
Channel:	Multilateral
Amount received:	834,183,750.00 Baht / 23,793,033.37 USD
Timeframe of the project:	2022 – 2027
Status:	Received
Sector and subsector:	Human settlements and security
Type of support:	Mitigation
Activity contributed to:	Capacity building
Status of project:	Ongoing

Project #18: EGAT Cooling Innovation Fund: CIF

Project description:	To foster the development of innovations in energy-efficient refrigeration technology and drive Thai industry toward the use of green refrigeration technology.
Channel:	Bilateral
Amount received:	180,000,000.00 Baht / 5,134,055.90 USD
Timeframe of the project:	2021-2024
Status:	Received
Sector and subsector:	IPPU
Type of support:	Mitigation
Activity contributed to:	Technology development and transfer
Status of project:	Ongoing

Project #19: Climate Action Programme for the Chemical Industry (CAPCI)

Project description:	The Project aims to enable key actors in the chemical industry to identify and tap mitigation potentials in chemicals production and associated value chains. The first phase focuses on information, knowledge, and awareness creation as well as stakeholder dialogue. The second phase focuses on action-oriented capacity building, training, and technical advice. It is a global project covering 5 countries: Argentina, Ghana, Peru, Thailand, and Vietnam.
Channel:	Bilateral
Amount received:	73,740,000.00 Baht / 2,103,251.57 USD
Timeframe of the project:	2021-2024
Status:	Received
Sector and subsector:	Multi-Sector
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #20: The ASEAN Carbon Pricing Conference

Project description:	The ASEAN Carbon Pricing Conference aims to highlight the role of carbon pricing instruments, including carbon crediting mechanisms, in accelerating climate action as well as the future role of carbon markets, particularly in contributing to the transition towards the net zero greenhouse gas emissions. The Conference will serve as the venue for all relevant stakeholders to discuss, exchange, and learn from one another in identifying the key success factors. It is also expected to explore the potential regional collaboration and opportunity on the regional integrated carbon market in order to enhance the effectiveness of the carbon pricing implementation in the Southeast Asia region.
Channel:	Multilateral
Amount received:	1,500,000.00 Baht / 42,783.80 USD
Timeframe of the project:	2023
Status:	Received
Sector and subsector:	Mechanism Strengthening
Type of support:	Mitigation
Activity contributed to:	Financial support
Status of project:	Completed

Project #21: Accelerating the adoption and life-cycle solutions to electric mobility in Thailand

Project description:	This project aims at 1) developing a system for analyzing, forecasting and managing GHG emissions in the transport sector, 2) developing an integrated charging infrastructure plan with renewable energy systems, 3) providing both financial and non-financial incentives for electric vehicles in the public and private sectors, 4) improving battery life cycle issues for electric vehicles and sustainable battery use, and 5) supporting entrepreneurs for electric vehicle use.
Channel:	Multilateral
Amount received:	1,010,567,476.64 Baht / 28,823,944 USD
Timeframe of the project:	2024-2029
Status:	Received
Sector and subsector:	Transport
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #22: Capacity building on formulating a system to collect information for inventory and mitigation estimation serving biennial transparency reports (BTR)

Project description:	To support DCCE to develop a data collecting system to collect information for reporting national GHG emissions inventory and mitigation information basis of enhance transparency framework supports reporting on biennial transparency reports (BTR).
Channel:	Multilateral
Amount received:	1,753,000.00 Baht / 50,000.00 USD
Timeframe of the project:	2023-2024
Status:	Received
Sector and subsector:	All sectors
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #23: Thai Rice GCF (Strengthening Climate-Smart Rice Farming Project)

Project description:	The Rice Department, in collaboration with GIZ, has developed a proposal for the Strengthening Climate-Smart Rice Farming Project (Thai Rice GCF) to request support from the Green Climate Fund (GCF). The project aims to shift the paradigm to low-carbon rice farming and enhance resilience to climate change by promoting rice farming with climate-smart technology (CSA) in 21 target provinces. The project involves 4 operational units: the Rice Department, the Office of Natural Resources and Environmental Policy and Planning, the Bank for Agriculture and Agricultural Cooperatives, and the International Rice Research Institute (IRRI).
Channel:	Multilateral
Amount received:	4,350,660,000.00 Baht / 124,091,842.56 USD
Timeframe of the project:	2024–2028
Status:	Received
Sector and subsector:	Agriculture sector
Type of support:	Mitigation
Activity contributed to:	Technology development and transfer and capacity-building
Status of project:	Ongoing

Project #24: IKI Support Project - NDC

Project description:	Support project NDC implementation and ambition raising in IKI partner countries
Channel:	Multilateral
Amount received:	484,569,231.19 Baht / 13,821,141.79 USD
Timeframe of the project:	2020-2024
Status:	Received
Sector and subsector:	Multi-sector
Type of support:	Mitigation
Activity contributed to:	Financial support
Status of project:	Completed

Project #25: Thai rice NAMA

Project description:	Thai Rice NAMA is a cooperative project between MOAC and GIZ, funded by NAMA Facility. This project, implemented from 2018 to 2023, promotes converting from traditional to sustainable rice cultivation or GAP++ by adopting Alternative wetting and drying (AWD), site-specific nutrient management (SSNM), and crop residue management. The project targets are 100,000 farmer households in Thailand's Central plain area (6 provinces)
Channel:	Bilateral
Amount received:	298,673,362.05 Baht / 8,518,920.77 USD
Timeframe of the project:	2018-2024
Status:	Received
Sector and subsector:	Agriculture
Type of support:	Mitigation
Activity contributed to:	Financial support, Technology development and transfer and capacity-building
Status of project:	Completed

Project #26: Proliferation of sustainable consumption and production (SCP) in Asia

Project description:	In recent years, sustainable public procurement and environmental labelling have become increasingly important in South-eastern Asia. Aided by Thailand, the project supports the development and implementation of environmental labels, as well as sustainable consumption and production patterns in five developing Asian countries. It is geared to country-specific needs and focuses on strengthening institutions, specialist training courses, knowledge transfer and integrated solutions at regional level. The project also supports trans-national knowledge sharing events and stakeholder meetings to define core criteria for eco-labelling and Green Public Procurement (GPP) in the ASEAN Economic Community. Additionally, it supports the partner institutions in integrating climate-friendly and low-carbon criteria into eco-labels and analyses international best practices in the field of GPP to this end.
Channel:	Multilateral
Amount received:	184,350,000.00 Baht / 5,258,128.92 USD
Timeframe of the project:	2020-2024
Status:	Received
Sector and subsector:	Multi-sector
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #27: Orientation of infrastructure investments on the goals of the Paris Agreement and the 2030 Agenda in Central and Southeast Asia (SIPA)

Project description:	Over 60 percent of global greenhouse gas (GHG) emissions derive from existing infrastructure systems. What is built in the next several years will set GHG trajectories for decades. Against the background of the design of post-COVID recovery plans, there is a unique opportunity to help direct investments towards energy, transport and industry infrastructure projects that not only support economic growth in the short term, but are also consistent with long-term climate goals. To achieve this, the project supports partner countries in prioritizing infrastructure projects compatible with long-term low-emission, resilient development pathways. Support includes enabling policy frameworks to scale up investments in low-emission infrastructure. The project cooperates with the private sector and financial stakeholders to promote Responsible Business Conduct and green, inclusive finance and investment principles; and fosters capacities, knowledge creation, policy dialogue and peer learning.
Channel:	Multilateral
Amount received:	725,525,758.41 Baht / 20,693,832.24 USD
Timeframe of the project:	2021 - 2025
Status:	Received
Sector and subsector:	Multi-sector
Type of support:	Mitigation
Activity contributed to:	-
Status of project:	Ongoing

Project #28: Scaling Sustainable Consumption and Production (SCP): Ecolabelling and Green Public Procurement (GPP) for a Low-Carbon Pathway in ASEAN (Scaling SCP)

Project description:	Southeast Asia's economies are growing rapidly and markets are flooded with unsustainable products. To mitigate greenhouse gas emissions, the project strengthens more sustainable consumption patterns in partner countries. Measures include promoting eco-labeling and sustainable public procurement in large public institutions and cities. The project supports the coordination of policy instruments, and develops institutional and technical competencies, as well as environmental product criteria for climate-relevant goods. In addition, the project fosters regional and international dialogue and exchange of experience on eco-labeling and sustainable public procurement. Thereby, the project contributes to the United Nations' Ten-Year Framework for the Promotion of Sustainable Consumption and Production Patterns.
Channel:	Multilateral
Amount received:	106,923,000.00 Baht / 3,049,714.77 USD
Timeframe of the project:	2022 - 2024
Status:	Received
Sector and subsector:	Multi-sector
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #29: SCP Asia Phase II - sustainable consumption and production in Thailand and Cambodia

Project description:	In order to improve the environmental performance of agricultural products in partner countries, the project promotes sustainable forms of consumption and production. By bringing together different stakeholders along the value chain, it stimulates the production of more sustainable agri-food products. In model regions, the project develops nature-friendly cultivation practices and creates value chains to open up markets. In addition, the project increases the demand for nature-friendly, low-carbon products among consumers and empowers them to make informed purchasing decisions through sustainability information. For scalability, the project engages in local, national and global policy-making processes and supports governments in integrating sustainability consumption and production principles into coherent policies in line with climate, biodiversity and SDG targets.
Channel:	Multilateral
Amount received:	110,522,544.36 Baht / 3,152,382.90 USD
Timeframe of the project:	2022-2026
Status:	Received
Sector and subsector:	Multi-sector
Type of support:	Mitigation
Activity contributed to:	-
Status of project:	Ongoing

Project #30: The Asia Low Carbon Buildings Transition (ALCBT)

Project description:	Buildings and space cooling are the main drivers for the growing future electricity demand and rising GHG emissions in Asia. The project addresses regulatory, capacity and financing gaps that prevent large scale adoption of low carbon buildings. The project develops technical and institutional capacity for city/state governments. To transform existing and new buildings towards carbon neutrality by 2050, the project focuses on enhancing capacity to achieve regional and national ambition and targets for low carbon buildings, with policy recommendations. It establishes common metrics (Taxonomy/MRV system) and central registry for certified buildings. Through building certification and business model innovation, the project tries to mobilize public and private finance. To raise awareness and promote replication locally and globally, the project will share the best practices and showcases.
Channel:	Multilateral
Amount received:	662,865,082.80 Baht / 18,906,591.07 USD
Timeframe of the project:	2023-2028
Status:	Received
Sector and subsector:	Multi-sector
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #31: Urban climate action: pilot projects under Article 6 of the Paris Agreement in Indonesia & Thailand

Project description:	Cities cause over 40% of direct global CO_2 emissions. However, mobilizing significant emission reductions in cities is a major challenge due to the very heterogeneous urban structures. The project develops pragmatic approaches for the implementation of activities in cities corresponding to Article 6 of the Paris Agreement. In other words, the project pilots the integration of cities in the global emission trading system. A particular focus is on the involvement of relevant actors at the local, national, and international levels. Furthermore, pragmatic structures and distribution mechanisms for Article 6 will be conceptualized with the partners and relevant actors in the target countries. The expected outcome of the project is to have at least one pilot city in each country that is able to generate emission certificates according to Article 6.
Channel:	Multilateral
Amount received:	18,033,815.69 Baht / 514,370.10 USD
Timeframe of the project:	2021-2025
Status:	Received
Sector and subsector:	Multi-sector
Type of support:	Mitigation
Activity contributed to:	Financial support
Status of project:	Ongoing

Project #32: Global Climate Partnership Fund

Project description:	To limit global heating and, therefore, the impacts of climate change, investment is required in energy efficiency, renewables and measures that mitigate the emission of greenhouse gases. The Global Climate Partnership Fund (GCPF) offers this kind of financing to developing and emerging countries. Funding is provided either as a direct investment in specific projects or made available to local financial institutions. These institutions then disburse the funds in the form of loans to small and medium-sized businesses or private households. The GCPF is registered in Luxembourg and is managed by responsibility Investments AG. The Fund increases the effectiveness of public money by mobilizing additional financing from public and private investors for climate mitigation projects.
Channel:	Multilateral
Amount received:	3,004,905,000.00 Baht / 85,707,501.43 USD
Timeframe of the project:	2009-2030
Status:	Received
Sector and subsector:	Multi-sector
Type of support:	Mitigation
Activity contributed to:	Financial support
Status of project:	Ongoing

Project #33: Strategic Environmental Dialogues

Project description:	The 2030 Agenda and the Paris Agreement on Climate Change call for the global transformation of economies and lifestyles, providing new impetus for sustainable development. The accompanying international commitments pose complex challenges for many countries and generate demand for practicable approaches for coherent implementation. On behalf of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), the project supports dialogue and exchange formats with political decision-makers and key actors from business, science, and civil society in emerging and developing countries. Within the framework of the cooperation, innovative cross-sectoral concepts and formats are developed and initiatives on selected thematic focal points are supported to contribute to the international alignment of interests and exchange of experience as well as to development in the partner countries.
Channel:	Multilateral
Amount received:	510,649,500.00 Baht / 14,565,017.11 USD
Timeframe of the project:	2014-2027
Status:	Received
Sector and subsector:	-
Type of support:	Mitigation
Activity contributed to:	-
Status of project:	Ongoing

Project #34: Green Banking - Capacity Building for Green Energy and Climate Finance

Project description:	In developing and emerging countries, financial resources for expanding sources of renewable energy and for energy efficiency measures are often lacking, since banks and investors lack expertise in such technologies. The end result is that risks are overestimated and projects do not come to fruition. The Green Banking initiative tackles this problem by offering an extensive programme of scholarships and further training that covers all aspects of green and climate financing. A key focus of the programme is training to become a certified 'Green Energy Finance Specialist', which is aimed at bank employees and independent investors. The course is also supplemented by a train-the-trainer and mentoring programme to selected participants to ensure a sustainable knowledge transfer into banks and financial institutions.
Channel:	Multilateral
Amount received:	296,776,271.14 Baht / 8,464,810.93 USD
Timeframe of the project:	2015-2026
Status:	Received
Sector and subsector:	Multi-sector
Type of support:	Mitigation
Activity contributed to:	Financial support
Status of project:	Ongoing

Project #35: NDC Support Programme

Project description:	The project helps countries to comply with their Paris Agreement commitments, to build institutional and technical resources and skills through technical and financial assistance for climate change mitigation, and to develop the global knowledge exchange and peer-to-peer learning for leadership and awareness raising. Policy and financing options for the implementation and mainstreaming of LEDS and mitigation activities are identified, and opportunities, costs, barriers, and risks involved in NDC solutions analyzed. Countries are given specific advice on their Partnership Plans drawn up through the NDC Partnership and its Climate Action Enhancement Package (CAEP), and on the support needs identified therein, to generate impacts and learning, and the project responds directly to government requests. The project ensures that NDC implementation becomes the driving force for sustainable development, advances gender equality, the transition to carbon-free economies, and the achievement of the SDGs.
Channel:	Multilateral
Amount received:	1,622,280,000.00 Baht / 46,271,534.51 USD
Timeframe of the project:	2017-2024
Status:	Received
Sector and subsector:	Multi-sector
Type of support:	Mitigation
Activity contributed to:	Financial support
Status of project:	Ongoing

Project #36: Green Cooling Initiative III

Project description:	Rising temperatures, growing populations and increasing prosperity are increasing the global demand for cooling. At the same time, conventional cooling technologies lead to an increase in greenhouse gas emissions and damage to the ozone layer. The project strengthens key actors in public and private sector institutions in the partner countries to make their refrigeration and air conditioning sectors sustainable and to achieve their goals within the framework of multilateral agreements such as the Montreal Protocol. In concrete terms, the project supports the implementation of regionally adapted sustainable sector strategies and effectively introduces the issue of sustainable cooling into the national climate discourse. It also makes financing instruments for green cooling technologies more widely available and establishes a training system for refrigeration and air conditioning technicians.
Channel:	Multilateral
Amount received:	239,655,000.00 Baht / 6,835,567.60 USD
Timeframe of the project:	2021-2025
Status:	Received
Sector and subsector:	IPPU
Type of support:	Mitigation
Activity contributed to:	Financial support, Technology development and transfer and capacity-building
Status of project:	Ongoing

Project #37: Innovation Regions for a Just Energy Transition

Project description:	The global energy transition away from coal to renewable energy is threatening local livelihoods, economic activities and jobs, but also is holding opportunities for sustainable, low carbon development. The project aims at supporting key stakeholders of coal regions to plan for and implement regional just energy transition pathways away from coal and towards a low-carbon energy system. Focusing on the regional economic transformations, the project works with government, industry, unions, communities, civil society, and academia. It supports interregional peer-to-peer exchange, learning, and policy dialogue in an international network and information sharing via a knowledge hub. In Indonesia, it supports the development of specific transition plans in two coal regions. In Colombia, it supports the development of the concept and framework for energy communities and the implementation of just and inclusive energy communities in César and la Guajira.
Channel:	Multiateral
Amount received:	737,127,355.57 Baht / 21,024,739.18 USD
Timeframe of the project:	2022-2026
Status:	Received
Sector and subsector:	Energy
Type of support:	Mitigation
Activity contributed to:	Financial support and Technology development and transfer
Status of project:	Ongoing

Project #38: Supporting Preparedness for Article 6 Cooperation (SPAR6C)

Project description:	To engage the private sector in the implementation of nationally determined climate contributions (NDCs) and raise ambition, the project uses cooperative approaches under Article 6 of the Paris Climate Agreement. This promotes the development of a cost-effective carbon market. The project facilitates the development of transformative pilot projects for specific internationally transferred mitigation actions (ITMOs) through research-based capacity building in four partner countries. The project develops best practice tools and approaches for the implementation of cooperation mechanisms. The country-specific implementation in each of the countries focuses on the three work areas "long-term climate change planning", "institutional preparation for possible transactions" and "design and implementation of Article 6 pilot projects".
Channel:	Multilateral
Amount received:	737,400,000.00 Baht / 21,032,515.69 USD
Timeframe of the project:	2022-2027
Status:	Received
Sector and subsector:	Multi-sector
Type of support:	Mitigation
Activity contributed to:	Financial support
Status of project:	Ongoing

Project #39: Clean Energy Transitions Programme (CETP)

Project description:	Clean Energy Transitions Programme (CETP) is IEA's flagship programme for taking action to achieve a clean energy transformation worldwide. By helping countries around the world, particularly in emerging and developing economies, make the right choices for their energy future, it seeks to ensure a secure, sustainable energy future for all. Activities include data and analytical work, technical cooperation, policy advice and implementation, tracking the scale and speed of transitions, training and capacity building, and strategic/political dialogues. Work is delivered across three key pillars, accelerating National and Regional transitions, supporting outcomes of key global fora and shaping the global dialogue on issues of common interest and importance. The life of the CETP has coincided with possibly the most impactful and successful period in the IEA's history, helping build its reputation as the world's leading and most respected energy adviser.
Channel:	Multilateral
Amount received:	221,220,000.00 Baht / 6,309,754.71 USD
Timeframe of the project:	2024-2025
Status:	Received
Sector and subsector:	Energy
Type of support:	Mitigation
Activity contributed to:	Financial support and capacity-building
Status of project:	Ongoing

Project #40: Inclusive Sustainable Rice Landscapes in Thailand - GEF

Project description:	The ISRL project is funded by the Global Environment Facility (GEF) through a multi-focal area grant to address Biodiversity, Land Degradation, Climate Mitigation, and Food Systems, Land Use and Restoration (FOLUR) and by Germany's Federal Ministry for Economic Cooperation and Development (BMZ), to transform agricultural production landscapes in Thailand (Ubon Ratchathani and Chiang Rai) to balance social, economic, and environmental interests.
Channel:	Multilateral
Amount received:	2,553,628,862.78 Baht / 72,835,963.00 USD
Timeframe of the project:	2020-2025
Status:	Received
Sector and subsector:	Agriculture
Type of support:	Mitigation
Activity contributed to:	Financial support and Technology development and transfer
Status of project:	Ongoing

Supports for adaptation sectors

Project #1: Enhancing Climate Resilience in Thailand through Effective Water Management and Sustainable Agriculture

Project description:	To promote effective water resource management by strengthening the integrity of water management infrastructure.
Channel:	Bilateral
Amount received:	1,188,930,984.38 Baht / 33,911,323.00 USD
Timeframe of the project:	2022-2027
Status:	Received
Sector and subsector:	Water Management
Type of support:	Adaptation
Activity contributed to:	Capacity building
Status of project:	Ongoing

Project #2: Capacity Building in Health Systems Resilience to Climate Change in Thailand

Project description:	Capacity building in health systems resilience to climate change in Thailand
Channel:	Bilateral
Amount received:	36,783,724.20 Baht / 1,049,164.98 USD
Timeframe of the project:	2023
Status:	Received
Sector and subsector:	Public health
Type of support:	Adaptation
Activity contributed to:	Capacity building
Status of project:	Complete

Project #3: Training of Trainer on Climate Change and Health Adaptation Project

Project description:	The project aims to build and develop the potential of public health officials to have knowledge and understanding of the impacts of climate change and health, to be able to transfer and disseminate to practitioners at the local level, and to be able to integrate policies, projects or plans on health adaptation and climate change at the local level.
Channel:	Bilateral
Amount received:	25,809,000.00 Baht / 736,138.05 USD
Timeframe of the project:	2022 - 2023
Status:	Received
Sector and subsector:	Public health
Type of support:	Adaptation
Activity contributed to:	Financial support
Status of project:	Complete

Project #4: Urban Resilience: Building and Nature

Project description:	To develop pilot cities in the target areas that can adapt socially, economically and environmentally to climate change through policy mechanisms, economic and social development plans, responding to the impacts and risks of climate change, and sustainable development, developed by potential local government organizations. In addition, the framework of Nature-based Solutions is applied in the area.
Channel:	Bilateral
Amount received:	258,090,000.00 Baht / 7,361,380.49 USD
Timeframe of the project:	2022 - 2028
Status:	Received
Sector and subsector:	Water resources management
Type of support:	Adaptation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #5: Mekong EbA South: Enhancing Climate Resilience in the Greater Mekong Sub-region through Ecosystem-based Adaptation in the Context of South-South Cooperation

Project description:	To enhance awareness and actions of government and local communities in the Mekong River Basin subregion for climate change adaptation through ecosystem-based approaches.
Channel:	Bilateral
Amount received:	245,420,000.00 Baht / 7,000,000.00 USD
Timeframe of the project:	2017-2027
Status:	Received
Sector and subsector:	Multi-sector
Type of support:	Adaptation
Activity contributed to:	Financial support
Status of project:	Ongoing

Project #6: Enhancing climate resilience in Thailand through effective water management and sustainable agriculture: E-WMSA

Project description:	The project promotes water management for agriculture and the community in the Chaopraya basin
Channel:	Bilateral
Amount received:	614,724,510.00 Baht / 17,533,500.00 USD
Timeframe of the project:	2023-2026
Status:	Received
Sector and subsector:	Human settlements and security
Type of support:	Adaptation
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #7: Support Programme on Scaling up Climate Ambition on Land Use and Agriculture through NDCs and National Adaptation Plans (SCALA)

Project description:	With climate change threatening the agriculture sectors, livelihoods and food security, there is an urgent need for scaled action to cope with climate-related impacts. In response to that, SCALA supports 12 countries in Africa, Asia and Latin America both to build adaptive capacity and to implement low emission priorities in agriculture and land use. The programme uses a multi-stakeholder approach, harnessing strong engagement from the private sector and key national institutions. National activities focus on strengthening policies, and appraising and adopting innovative approaches, as well as removing key barriers related to information gaps, governance, finance, gender mainstreaming, and integrated monitoring and reporting. The ultimate goal is for countries to turn agricultural related priorities laid out in their National Adaptation Plans (NAPs) and Nationally Determined Contributions (NDCs) into action.
Channel:	Multilateral
Amount received:	737,400,000.00 Baht / 21,032,515.69 USD
Timeframe of the project:	2019-2025
Status:	Received
Sector and subsector:	Food security
Type of support:	Adaptation
Activity contributed to:	Financial support and capacity-building
Status of project:	Ongoing

Project #8: Assessment and Communication of Climate Impacts of Food

Project description:	Food production and consumption account for a large share of global greenhouse gas emissions and have a negative impact on biodiversity. Although there are already many labels that are supposed to support more sustainable purchasing, these only cover partial aspects of sustainability. Companies and consumers are unable to recognize the criteria behind them. Needs-based communication channels are lacking. The project enables companies and consumers to inform themselves about complex impacts when consuming and purchasing and thus to make more sustainable decisions. To this end, a target group-oriented tool is being developed, which will be piloted in Germany, Paraguay, South Africa and Thailand and will be applied globally in the long term. In this way, more sustainable purchasing decisions will promote the demand for more resource-efficient products within the planetary impact limits.
Channel:	Multilateral
Amount received:	122,873,256.96 Baht / 3,504,656.50 USD
Timeframe of the project:	2021-2024
Status:	Received
Sector and subsector:	Food security
Type of support:	Mitigation
Activity contributed to:	Financial support
Status of project:	Ongoing

Supports for cross-cutting sectors

Project #1: Decarbonization of industry and the building sector in Thailand through the adoption of integrated net-zero and nature-positive solutions.

Project description:	Decarbonization of industry and the building sector to reduce significant GHG emissions by 2030, through the adoption of integrated net-zero and nature-positive solutions.
Channel:	Multilateral
Amount received:	233,733,309.96 Baht / 6,666,666.00 USD
Timeframe of the project:	2022-2025
Status:	Received
Sector and subsector:	Transport sector
Type of support:	Cross-Cutting
Activity contributed to:	Financial support and technology development and transfer and capacity-building
Status of project:	Planned

Project #2: Development of Climate Action Plan at the City Level Project

Project description:	This project aims at (1) enabling the city to understand how to estimate the amount of greenhouse gas emissions within its administrative area and support the city to set greenhouse gas reduction targets, (2) analyzing greenhouse gas reduction measures appropriately for the city's context, (3) developing the city's Climate Action Plan (CAP), and (4) developing policy proposals and the city's climate action plan.
Channel:	Multilateral
Amount received:	2,114,226.43 Baht / 60,303.09 USD
Timeframe of the project:	2022-2023
Status:	Received
Sector and subsector:	Cross-Cutting
Type of support:	Mitigation
Activity contributed to:	Capacity-building
Status of project:	Completed

Project #3: Thai Rice GCF: Strengthening Climate-Smart Rice Farming

Project description:	To provide better climate information and forecasts, promoting climate-resilient agricultural practices, and improving access to markets and finance.
Channel:	Bilateral
Amount received:	1,401,060,000.00 Baht / 39,961,779.81 USD
Timeframe of the project:	2023 - 2026
Status:	Received
Sector and subsector:	Cross-Sector
Type of support:	Cross-cutting
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #4: Institutional Strengthening of National Ozone Unit (IS)

Project description:	1. To provide knowledge and understanding of ozone conservation to the public. 2. To advertise about reducing and stopping the destruction of the ozone layer, ozone conservation and other projects. 3. To participate in meetings, determining the direction of operations, supporting and promoting, and building the capacity for operations related to ozone conservation, controlling ozone-depleting substances, setting criteria and policies, etc.
Channel:	Multilateral
Amount received:	10,000,000.00 Baht / 285,225.33 USD
Timeframe of the project:	2020-2025
Status:	Received
Sector and subsector:	IPPU
Type of support:	Cross-cutting
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #5: Effectively Managing Networks of Marine Protected Areas in Large Marine Ecosystems in the ASEAN Region (ASEAN ENMAPS)

Project description:	To study scientific approaches to support and expand the network of marine protected areas (MPAs), learning knowledge management and networking, strengthening the management capacity of marine protected areas networks of stakeholders, promoting the management of marine protected areas networks to conserve and use biodiversity sustainably.
Channel:	Bilateral
Amount received:	2,470,205,135.42 Baht / 70,456,507.00 USD
Timeframe of the project:	30 August 2024 - 31 December 2028
Status:	-
Sector and subsector:	LULUCF
Type of support:	Cross-cutting
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #6: Developing GCF pipeline of projects from locally driven climate actions

Project description:	To enhance the capacity of local communities to adopt climate mitigation measures.
Channel:	Bilateral
Amount received:	12,270,964.94 Baht / 349,999.00 USD
Timeframe of the project:	2022-2024
Status:	Received
Sector and subsector:	Mechanism and strengthening
Type of support:	Cross-cutting
Activity contributed to:	Financial support and capacity-building
Status of project:	Completed

Project #7: Application of industry-urban symbiosis and green chemistry for low emission and persistent organic pollutants free industrial development in Thailand

Project description:	(1) To develop policy, (2) To strengthen national capacity and raise awareness on industry-community synergies and persistent organic pollutants, (3) to demonstrate activities on the application of clean production approaches, management of new persistent organic pollutants and industry-community synergies, and (4) to develop the framework of an eco-industrial city.
Channel:	Bilateral
Amount received:	4,190,000,000.00 Baht / 119,509,412.44 USD
Timeframe of the project:	5 Years (1 September 2020 - 31 August 2025)
Status:	Received
Sector and subsector:	Mechanism Strengthening
Type of support:	Cross-cutting
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #8: Building project pipeline capacities: development of GCF concept notes in the transport and health sectors in Thailand

Project description:	The Project seeks to enhance Thai agencies' capacity to approach the Green Climate Fund for climate mitigation and adaptation.
Channel:	Bilateral
Amount received:	19,080,423.32 Baht / 544,222.00 USD
Timeframe of the project:	2022-2024
Status:	Received
Sector and subsector:	Institutional Strengthening
Type of support:	Cross-cutting
Activity contributed to:	Capacity-building
Status of project:	Completed

Project #9: Green Climate Fund Readiness (GCF Readiness)

Project description:	The objective of this project is to develop the concept of the low-carbon intercity bus system with climate-proof infrastructure in Thailand and change the existing buses of the Transport Company to electric buses. The DCCE works together with the Office of Transport and Traffic Policy and Planning (OTP).
Channel:	Bilateral
Amount received:	16,591,500.00 Baht / 473,231.60 USD
Timeframe of the project:	2022-2023
Status:	Received
Sector and subsector:	Transport
Type of support:	Cross-cutting
Activity contributed to:	Capacity-building
Status of project:	Completed

Project #10: Strengthening Thailand's institutional and technical capacities to comply with the Enhanced Transparency Framework of the Paris Agreement - GEF

Project description:	The Project aims to strengthen Thailand's institutional and technical capacities to comply with the Enhanced Transparency Framework of the Paris Agreement. The Project consists of 4 elements: 1) enhance the capacity to collect data activity for the GHG inventory, 2) enhance the capacity of MRV systems for NDC implementation, 3) elevate the assessment of received funds for NDC implementation, and 4) enhance the transparency of adaptation and mitigation measures.
Channel:	Bilateral
Amount received:	69,804,460.00 Baht / 1,991,000.00 USD
Timeframe of the project:	2020-2026
Status:	Received
Sector and subsector:	Institutional Strengthening
Type of support:	Cross-cutting
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #11: Climate Policy and Biodiversity in Thailand

Project description:	Thailand is the second largest CO_2 emitter in Southeast Asia and ranks 13th globally in terms of its vulnerability to the impacts of climate change. Ambitious targets in key sectors continue to be hampered by capacity and data deficits. Frameworks for action need to be further strengthened and synergies between climate and biodiversity harnessed. Therefore, the project supports Thailand in developing policy guidelines, tools, and M&E for climate and biodiversity action. Mainstreaming of climate and biodiversity objectives will be promoted in the marine, coastal resources and sustainable tourism sectors. In collaboration with government representatives and relevant stakeholders, the project provides policy advice and supports capacity development and inter-ministerial exchange. The project also promotes regional and international dialogues and acts as an interface between the IKI and the Thai government.
Channel:	Bilateral
Amount received:	368,700,000.00 Baht / 10,516,257.84 USD
Timeframe of the project:	2022 - 2027
Status:	Received
Sector and subsector:	Cross-Sector
Type of support:	Cross-cutting
Activity contributed to:	Financial support and capacity-building
Status of project:	Ongoing

Project #12: Thailand's First Biennial Transparency Report (1BTR) and combined Fifth National Communication and Second Biennial Transparency Report (5NC/2BTR) to UNFCCC – GEF

Project description:	The objective of this Enabling Activity project is to assist Thailand in the preparation and submission of its First Biennial Transparency Report (1BTR) and combined Fifth National Communication and Second Biennial Transparency Report (5NC/2BTR) to UNFCCC for the fulfillment of the obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement (PA) in line with the Modalities, Procedures and Guidelines (MPGs) for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1) and the guidance on operationalizing the MPGs as per Decision 5/CMA.3. In addition, the project will also enable Thailand to prepare the progress update on its Adaptation Communication to the UNFCCC as it was communicated as a component of Fourth National Communication (4NC) in line with Article 7 of the PA and Decision 9/CMA.1.
Channel:	Bilateral
Amount received:	43,228,980.00 Baht / 1,233,000.00 USD
Timeframe of the project:	2024
Status:	Received
Sector and subsector:	Muti-sector
Type of support:	Cross-cutting
Activity contributed to:	Financial support
Status of project:	Ongoing

Project #13: Forests for Life - Intact Tropical Forest Landscape Conservation in Thailand – GEF

Project description:	To contribute to securing the long-term integrity of Thailand's primary forests to maximize Global Environmental Benefits related to carbon and biodiversity
Channel:	Multilateral
Amount received:	261,333,345.00 Baht / 7,453,888.90 USD
Timeframe of the project:	n/a
Status:	-
Sector and subsector:	LULUCF
Type of support:	Cross-cutting
Activity contributed to:	-
Status of project:	-

Project #14: Workshop on Enhancing Urban Biodiversity and Greenery Management in Urban Green Spaces in ASEAN

Project description:	To raise awareness and exchange experiences on green space operations in cities in various dimensions, including upgrading operations on green spaces and biodiversity in cities.
Channel:	Multilateral
Amount received:	3,928,203.54 Baht / 112,042.31 USD
Timeframe of the project:	2023
Status:	Received
Sector and subsector:	Mechanism Strengthening
Type of support:	Cross-cutting
Activity contributed to:	Capacity-building
Status of project:	Complete

Project #15: Conservation Seagrass Ecosystems – Safeguarding Food Security and Resilience in Vulnerable Coastal Communities

Project description:	Seagrass is an essential food source for dugongs and other marine wildlife and provides key ecosystem services (e.g. fisheries productivity and carbon sequestration). Seagrass ecosystems are declining globally due to pressure from coastal development, fishing and boating, pollution and climate change. Information on the status of seagrass ecosystems and the services that they provide is lacking. The project contributes to reducing these knowledge gaps by engaging local NGOs and communities in the conservation of seagrass. NGOs are trained in participatory science to enable them to collect data and identify key seagrass areas. This information is then used to engage communities and decision makers in developing policies for seagrass conservation. In parallel, the project implements alternative business models in coastal communities to improve livelihoods and contribute funds for seagrass conservation. This enhances the sustainability of seagrass ecosystems in the Indo-Pacific.
Channel:	Bilateral
Amount received:	194,673,600.00 Baht / 5,552,584.14 USD
Timeframe of the project:	2019-2025
Status:	Received
Sector and subsector:	Biodiversity
Type of support:	Cross-cutting
Activity contributed to:	Financial support and capacity-building
Status of project:	Ongoing

Project #16: Biodiversity Finance Initiative (BIOFIN II)

Project description:	The financing of biodiversity conservation is a key issue in the implementation of the Convention on Biological Diversity (CBD). Most countries lack reliable information on the actual costs to effectively implement their biodiversity strategies, nor do they know where the necessary funds can be sourced and how they can be used to implement their strategies. The BIOFIN initiative, active in 37 countries, is a global partnership that supports its partner countries by addressing these knowledge gaps. Financing solutions are being developed and implemented in a second step. BIOFIN Phase II, which is financed through the IKI Corona Response Package, focuses on four signature solutions: support countries to deal with the impacts of COVID-19, results based and effective budgeting for biodiversity, reducing harmful subsidies and expenditures and greening the financial sector.
Channel:	Bilateral
Amount received:	1,474,800,000.00 Baht / 42,065,031.37 USD
Timeframe of the project:	2018-2027
Status:	Received
Sector and subsector:	Biodiversity
Type of support:	Cross-cutting
Activity contributed to:	Capacity-building
Status of project:	Ongoing

Project #17: Thematic Trust Fund - Biodiversity and Ecosystem Services Network (BES-Net) phase II

Project description:	Putting a halt to nature's rapid decline requires urgent, collaborative solutions and actions. Through BES-Net, UNDP, UNEP-WCMC and UNESCO promote networking and cooperation among policymakers, scientists and practitioners to jointly design and implement solutions for effective management of biodiversity and ecosystem services, and long-term sustainable development. During its second phase, the project supports policymaking and transformative on-the-ground actions in a total of 18 countries through targeted seed funds. Building on the work of the Intergovernmental Science-Policy-Platform on Biodiversity and Ecosystem Services (IPBES), BES-Net II also extends its capacity-building support in four additional countries to undertake National Ecosystem Assessments and facilitates science-policy-practice triangular dialogues to help identify cutting-edge nature-based solutions in 40 countries. With a growing online platform, BES-Net's online channels disseminate news, events, jobs and research.
Channel:	Bilateral
Amount received:	737,400,000.00 Baht / 21,032,515.69 USD
Timeframe of the project:	2020-2028
Status:	Received
Sector and subsector:	Biodiversity
Type of support:	Cross-cutting
Activity contributed to:	Financial support and capacity-building
Status of project:	Ongoing

Project #18: Transformative pathways: indigenous peoples and local communities leading and scaling up conservation and sustainable use of biodiversity

Project description:	The project supports improved conservation and sustainable use of biodiversity by ensuring that the contributions of indigenous peoples and local communities are better recognized, supported and expanded, including in the implementation of the Kunming-Montreal Global Biodiversity Framework. It is led by a consortium of 13 organizations, a majority of whom are indigenous peoples' organizations. The project directly supports local initiatives for self-determined land and resource governance, producing sited, local, positive biodiversity and cultural outcomes, and co-development of community-owned monitoring frameworks to present evidence and demonstrate outcomes. Working with national and sub-national governments and other key actors, the project also co-develops mechanisms for full and equitable participation in national biodiversity-related policy and planning. These partnerships engage global CBD and IPBES processes through direct monitoring, reporting and dissemination of results.
Channel:	Bilateral
Amount received:	423,540,511.74 Baht / 12,080,448.14 USD
Timeframe of the project:	2020-2028
Status:	Received
Sector and subsector:	Biodiversity
Type of support:	Cross-cutting
Activity contributed to:	Financial support and capacity-building
Status of project:	Ongoing

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