MONGOLIA'S NATIONAL INVENTORY REPORT-2023

ANNEX TO SECOND BIENNIAL UPDATE REPORT TO UNFCCC

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LIST OF ABBREVIATIONS AND UNITS

ABBREVIATIONS

AAGR	Average Annual Growth Rate
AD	Activity Data
AFOLU	Agriculture, Forestry and Other Land Use
AGB	Above-Ground Biomass
ALAMGAC	Agency for Land Administration and Management Geodesy and Cartography
ALGAS	Asia Least-Cost Greenhouse Gas Abatement Strategy
AUIPG	Altai-Uliastai Integrated Power Grid
BAU	Business as Usual
BCEFs	Below-Ground Carbon and Expansion Factors
BGB	Below-Ground Biomass
BOD	Biochemical Oxygen Demand
BTR	Biennial Transparency Report
BUR	Biennial Update Report
BUR2	Second Biennial Update Report
CCAC	Climate and Clean Air Coalition
CCICD	Climate Change International Cooperation Department
CCMP	Climate Change Monitoring Plan
CCPIU	Climate Change Project Implementing Unit
CCRCC	Climate Change Research and Cooperation Centre
CE	Collect Earth
CGA	Customs General Administration
CHP	Combined Heat and Power Plant
COC	Coke Oven Coke
COD	Chemical Oxygen Demand
COG	Coke Oven Gas
COP	Conference of the Parties
CRF	Common Reporting Format
CRIPG	Central Region Integrated Power Grid
CS	Country Specific
CSC	Carbon Stock Change
DOC	Degradable Organic Carbon
DRI	Direct Reduced Iron
EAF	Electric Arc Furnace
EBTs	Energy Balance Tables
ECF	Environment and Climate Fund
EF	Emission Factor
EIC	Environmental Information Center
ERC	Energy Regulatory Commission
ERIPG	Eastern Region Integrated Power Grid
ERT	Expert Review Team
ETF	Enhanced Transparency Framework
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO Statistics
FOD	First Order Decay
FRA	Forest Resources Assessments
FRDC	Forest Research and Development Center
FRL	Forest Reference Level
GEF	Global Environmental Facility

GHG	Greenhouse Gas
GLs	Guidelines
GPG	Good Practice Guidance
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
HOB	Heat Only Boiler
HWP	Harvested Wood Products
iBUR	Initial Biennial Update Report
ICAO	International Civil Aviation Organization
IEA	International Energy Agency
ILF	Integrated Land Fund
ILT	Integrated Land Territory
INDCs	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IRIMHE	Information and Research Institute of Meteorology, Hydrology and Environment
JICA	Japan International Cooperation Agency
JSC	Joint Stock Company
KP	Kyoto Protocol to the UNFCCC
KPI	Key Performance Indicator
LLC	Limited Liability Company
LTO	Landing and Take-Off
LUC	Land Use Change
LULUCF	Land Use, Land Use Change and Forestry
MARCC	Mongolia Second Assessment Report on Climate Change
MCAA	Mongolian Civil Aviation Authority
MMACRA	Medical Appliance Control and Regulatory Agency
MCF	Methane Correction Factor
MDIs	Metered Dose Inhalers
MEEI	Mongolian Energy Economics Institute
MEGD	Ministry of Environment and Green Development
MET	Ministry of Environment and Tourism of Mongolia
MIAT	Mongolian Airlines
MMHI	Ministry of Mining and Heavy Industry of Mongolia
MOE	Ministry of Energy
MOFALI	Ministry of Food, Agriculture and Light Industry of Mongolia
MRPAM	Mineral Resources and Petroleum Authority of Mongolia
MRTD	Ministry of Road and Transport Development
MRV	Measuring, Reporting and Verification
MSW	Municipal Solid Waste
NAMAs	National Appropriate Mitigation Actions
NAMEM	National Agency Meteorology and the Environmental Monitoring
NCC	National Climate Committee
NCs	National Communications
NCV	Net Calorific Value
NDA	National Development Agency
NDC	Nationally Determined Contribution
NEMA	National Emergency Management Agency
NMVOC	Non-Methane Volatile Organic Compounds
NFI	National Forest Inventory of Mongolia
NFP	National Focal Point to the UNFCCC
NIR	National Inventory Report of Mongolia

NOA	National Ozone Authority of Mongolia
NSO	National Statistics Office of Mongolia
ODS	Ozone Depleting Substances
PA	Paris Agreement
PFCs	Perfluorocarbons
QA/QC	Quality Assurance and Quality Control
RA	Reference Approach of Energy Sector
RAC	Refrigeration and Air Conditioning
SA	Sectorial Approach of Energy Sector
SAR	Second Assessment Report of IPCC
SNC	Second National Communication of Mongolia
SOCref	Reference Value of Soil Organic Carbon
SRIPG	Southern Region Integrated Power Grid
SWDS	Solid Waste Disposal Sites
TAM	Typical Animal Mass
TFI	Taxation Forest Inventory
TNC	Third National Communication of Mongolia
TOW	Total Organically Degradable Material in Wastewater
UNCOMTRADE	United Nations Commodity Trade Statistics Database
UNEP	United Nations Environmental Program
UNFCCC	United Nations Framework Conference on Climate Change
UN-REDD	United Nations Reducing Emissions from Forest Degradation
USCSP	U.S. Country Studies Program
WA	Water Agency
WB	World Bank
WRIPG	Western Region Integrated Power Grid
WWTP	Wastewater Treatment Plant
XPS	Extrude Polystyrene

UNITS

%	percent
°C	degree Celsius
cap	capita
CO_2e	carbon dioxide equivalents
d.m.	dry matter
g	gram
Gg	Gigagram
Gcal	Gigacalories
ha	hectare
kg	kilogram
km	kilometre
kt	kilotonnes
kWh	kiloWatt hours
l	liter
m	metre
m^2	square metre
m^3	cubic metre
Mt	million tonnes
MW	MegaWatt
MWh	MegaWatt hours
t	tonnes
thous.	thousand
thous.heads	thousand heads
TJ	Terajoules
yr	year

Mongolia's Second National Inventory Report (NIR) has been prepared as a part of the second Biennial Update Report. The NIR contains updated accounts of greenhouse gas emissions from anthropogenic sources and removals by sinks for the period of 1990-2020.

The GHG emissions and removals have been estimated from the Energy (CRF 1), Industrial Processes and Product Use (IPPU, CRF 2), Agriculture (CRF 3), Land Use, Land Use Change and Forestry (LULUCF, CRF 4) and Waste (CRF 5), according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. In addition, the Good Practice Guidance (GPG) was used to improve and update default values.

The main greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (HFCs) as well as indirect gases carbon monoxide (CO), and nitrous oxides (NOx) in Mongolia.

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CHAPTER 1: INTRODUCTION

1.1 Background information on GHG inventories and climate change

Mongolia has signed the United Nations Framework Convention on Climate Change (UNFCCC) on 12th June of 1992 and ratified on 30th September of 1993. With respect to the Kyoto Protocol (KP) of the UNFCCC Mongolia has ratified on 15th December of 1999. Mongolia is a developing country and as a non-Annex I Party not obligated to reduce its GHG emissions under regulations of KP, but under the Paris Agreement (PA) Mongolia has set its targets to reduce GHG emissions compared to business as usual (BAU) scenario until 2030.

Mongolia's Second National Inventory Report (NIR) has been prepared as part of second Biennial Update Report. The NIR contains updated accounts of net greenhouse gas (GHG) emissions estimate for the period of 1990-2020.

The GHG inventory for the NIR has been compiled using the 2006 IPCC Guidelines for National Greenhouse Gas inventories (2006 IPCC GLs) and the NIR has been prepared according to the UNFCCC guidelines for the preparation of biennial update reporting for Parties not included in Annex I to the Convention (decision 2/CP.17, paragraph 40 and annex III of decision 2/CP.17).

Mongolia has completed its GHG inventories five times, namely, the first one in 1996 for the base year 1990 under the U.S. Country Studies Program (USCSP). This inventory was updated within the Asia Least-Cost Greenhouse Gas Abatement Strategy (ALGAS, a regional project implemented by the Asian Development Bank (ADB)). As part of enabling activities of preparation of the Mongolia's initial National Communication (GEF/UNEP), the GHG inventories were updated to 1998 for the third time. In accordance with the preparation of the Second National Communication (SNC) in 2010, the national GHG inventories have been compiled for the period of 1990-2006. Generally the Tier 1 method of the Revised 1996 IPCC Guidelines for National GHG Inventories (the revised IPCC 1996) was used and for all sectors except some subcategories of energy and agriculture sectors.

The previous GHG Inventory Report (NIR) was prepared as a part of initial Biennial Update Report (iBUR) in 2017 and it covered the period of 1990-2014 using the 2006 IPCC GLs and its Tier 1 and Tier 2 methods (country-specific EFs for coal types. Although during that time non-Annex I Parties are not obligated to use the 2006 IPCC GLs, Mongolia decided to transit the GHG inventory's estimation methods to the 2006 IPCC GLs. The report was submitted in 2017 and the Third National Communication (TNC) was submitted in 2018 to the UNFCCC secretariat, respectively. The preparation of NIR is not only meant to serve the purpose of meeting international report obligations, but it provides the basis for setting up national emissions reduction targets and Measurement, Reporting, and Verification (MRV) system for tracking them in national development policies, sustainable institutional arrangement, GHG inventory system and capacity building.

There were two main projects targeted to improve capacity building of the national GHG inventory of Mongolia, namely, "*Capacity development to establish a national GHG inventory cycle of continuous improvement*" conducted by the Japan International Cooperation Agency from 2017 to 2022 (JICA, 2022) and "*Strengthening Capacity in the Agricultural and Land-use Sectors for Enhanced Transparency in Implementation and Monitoring of Mongolia's Nationally Determined Contribution (NDC) under the Paris Agreement*" conducted by the United Nations Food and Agricultural Organization from 2019 to 2022 (GCP/MON/016/CBT, 2022) which funded by UNFAO. Projects were implemented in close coordination and collaboration with one another to achieve a potential improvement on Mongolia's GHG inventory.

The project for "Capacity development to establish a national GHG inventory cycle of continuous improvement" conducted for strengthening the national system enhancement, mainly focusing on the energy sector and the land use, land use change and forestry (LULUCF) sector and also improvements for the IPPU and Waste sectors, and cross sectoral issues were carried out within the framework of the project. Overall goal of the project was to ensure that the national GHG inventory is continuously improved based on cooperation with relevant institutions. Here, the main outputs targeted to improve Activity data and Emission factors of the national GHG inventory were:

1. Issues in the Energy sector of GHG inventory were identified and solutions were approached:
    - Cooperation with the Mongolian Energy Economics Institute (MEEI) and NSO an initial draft of national energy balance tables was created which will serve as the basis for country specific activity data in the energy sector for Mongolia's GHG inventory. The initial draft of national energy balance tables for the period 1990-2019, which had been prepared jointly by MEEI and NSO, will be finalized by aligning them with the International Energy Agency (IEA)'s energy balance tables, which is an international standard. In addition, the manual detailing the process and method of creating the national energy balance tables was developed by MEEI.
    - Identified and improved the causes of different values between the sectoral approach and the reference approach in iBUR.
    - Applied the ratio of jet fuel consumption by domestic and international flights for 2018 and 2019 to improve the calculation method used in the iBUR. Based on the average of the ratio of jet fuel consumption for domestic and international flights in 2018 and 2019 and the amount of jet fuel imported since 1990 (NSO), the activity data for domestic and international fuel consumptions were derived for entire time series.
2. Issues in the LULUCF sector of GHG inventory identified and solutions were approached:
    - In addition, set up six subcategories of land use according to the presence or absence of land conversion, and calculate a 20-year cumulative land conversion for entire time series.
    - The Land Use, Land Use Change and Forest (LULUCF) assessment for 1990-2020 was carried out by internationally accepted tool (the Collect Earth) with the support of high-resolution satellite images.
    - In 2019 and 2020, two field surveys were conducted in collaboration with Institute of Geography and Geoecology (IGG) and National University of Mongolia (NUM). The surveys included carbon pools of biomass and soil (SOC) by five ecological system classification (eco region) regions of Mongolia. Prepared a report summarizing the results of grassland-related surveys which is a priority issue for the sector. The data set can provide averaged biomass amount in each eco-region, but the relationship between the amount of biomass and the status of the degradation/management is still not clear due to data of the degraded status is not obtained for entire time series.
    - A guidance document that outlines the process from field survey to analysis for additional soil carbon and biomass carbon surveys in the future and improvement guidance and improvement to priority issues were developed in the LULUCF sector.
3. Issues in the IPPU sector of GHG inventory identified and solutions were approached:
    - Annual import volume of HFC is important as an activity volume for calculating emissions, thus surveyed the import volume of bulk refrigerants by refrigerant type and the average

refrigerant capacity per unit of pre-charged (pre-infused at the time of manufacture) refrigerants for equipment by model and refrigerant type from 2012 to 2015 and combined these data with customs records of equipment imports to calculate the import volume of pre-charged refrigerants. In this project above method was applied to data from 2016 to 2020 and estimated the HFC emissions for this inventory.

Main goal of "*Strengthening Capacity in the Agricultural and Land-use Sectors for Enhanced Transparency in Implementation and Monitoring of Mongolia's Nationally Determined Contribution (NDC) under the Paris Agreement*" project was to strengthen intuitional arrangement, enhance the transparency of climate change adaptation and mitigation-related activities in the AFOLU sector and improve the quality and flow of GHG inventory data, thus, strengthen technical and human capacity ensuring the national GHG inventory is continuously improved. Here, the main outputs targeted to improve Activity data and Emission factors of the national GHG inventory were:

Issues in AFOLU sector of GHG inventory identified and solutions were approached:

- The country-specific emission factor from native cattle was tested and the annual methane emission from native cattle was estimated by the natural zone based on the national livestock statistical data.
- Assessment on livestock productivities (live weight, milk and wool/cashmere yield) and the condition pastureland species was conducted based on the data collected at agro-meteorological observation stations representing three eco-regions of Mongolia.
- A gap analysis on data quality of annual synthetic N (fertilizer) and pesticides application, and tillage practices and burnt crop area was conducted for improving data collection.
- Analysis of available fire data from different sources was conducted to improve emission estimation results for forest and grassland fires for the full inventory period between 1990-2019.
- The guideline on converting the national Integrated Land Territory (ILT) classification into the IPCC classification was revised and the updated (ALAMGAC, 2021).
- In order to improve the forest sector related data quality, the biomass growth model was developed, forest mask for year of 2019/2020 was created and the National Forest Inventory (NFI) database.
- The validation of Saxaul forest distribution was performed using QGIS, ESRI, ArcGIS, and Maxar Premium Imagery service based on the existing forest inventory data.

Although, as mentioned above within framework of the two projects some improvement of the GHG inventory have been improved, but not every outcome of these projects included in the current report due to need of overview of the results by relevant experts from related professional organizations.

GREENHOUSE GASES COVERED

The inventory covers sources of GHG emissions which results from anthropogenic activities for direct GHGs, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), indirect GHGs such as nitrogen oxides (NO_x), carbon monoxide (CO), and hydrofluorocarbons (HFCs) and their removals by sinks. Net emissions have been presented in carbon dioxide equivalents (CO_2e) using the 100-year global warming potentials (GWPs) from the 1995 IPCC Second Assessment Report (SAR).

SECTORS COVERED

The GHG inventory has been conducted for key economic sectors that support Mongolia's economic development. The emissions/removals have been estimated from five sectors which defined by the 2006 IPCC GLs. The sectors are (1) Energy, (2) Industrial processes and product use, (3) Agriculture, (4) Land use, Land use change and Forestry and (5) Waste.

1.2 A description of the national inventory arrangements

1.2.1 Institutional, legal and procedural arrangements

The Article 24 of the Law on Air (1995; 2012) states that "the designated government authority shall estimate the emissions and removals of GHGs of Mongolia following the methodologies approved by the Conference of Parties (COP) to the UNFCCC".

At national level, the Ministry of Environment and Tourism (MET), the central government body responsible for the development and implementation of climate change policies, and liaises the national, subnational, and local as well as international stakeholders. Thus, the MET and its Climate Change and International Cooperation Department (CCICD) are the national entities with overall responsibility for organizing and coordinating the compilation of National Communications, Biennial Updated Reports, GHG inventory and submitting them to the UNFCCC Secretariat through the National focal point for the UNFCCC.

In order to facilitate smooth implementation of commitments under UNFCCC, the MET established climate change project implementing unit (CCPIU) at the Environment and Climate Fund (ECF) under the ministry in 2015.

Since May 2020 the Climate Change Research and Cooperation Centre (CCRCC) has been established by the Cabinet based on functions of former CCPIU. Although the CCRCC was established as a self-financing state-owned enterprise, the former project unit, the CCPIU, is still fully operational with old staff and preparing reports for the implementation of the UNFCCC. The CCPIU is currently preparing the Fourth National Communication, National Inventory Report, and Second Biennial Update Report. The inventory team of CCPIU, which consists of four sectorial experts, with the cooperation of relevant ministries, agencies and organizations, prepares national GHG inventory and compiles supplementary information.

Figure 1-1 shows the overall institutional arrangement for Mongolia's inventory preparation. More detailed information on the role and responsibility of relevant ministries, agencies and organizations in the inventory preparation process is described in the Table 1-1.

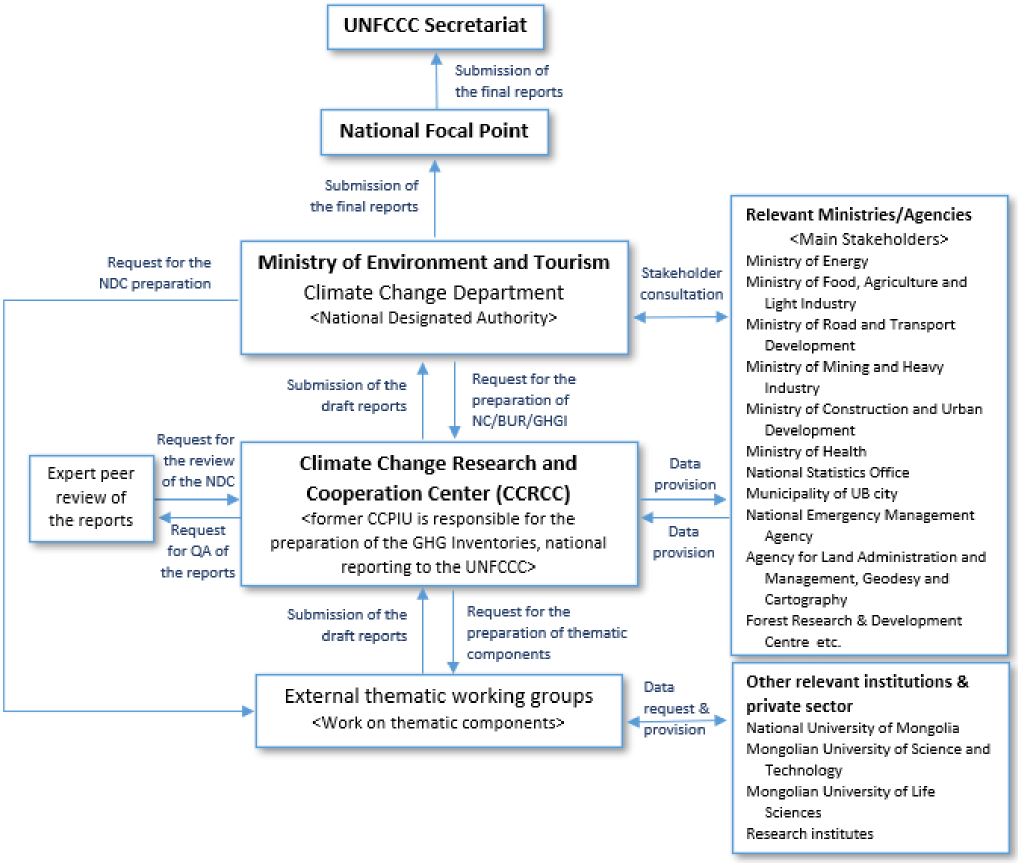

Figure 1-1. Institutional arrangements for preparation of the national GHG inventory and national reports to the UNFCCC

Conducting GHG inventory is a challenging task which requires technical knowledge of the UNFCCC reporting requirements and IPCC methodologies, and other varying technical and analytical skills. In Table 1-1, roles, responsibilities, and required capacities of the main stakeholders engaged in the GHG inventory process are presented.

Table 1-1: Roles, responsibilities, and capacities required for GHG inventories

Individuals/Entities	*Roles and responsibilities*	*Staff capacities required*
National focal point	- Submission of the GHG inventory - Communication with UNFCCC	- Knowledge about the UNFCCC procedures and reporting guidelines/requirements
Ministry of Environment and Tourism	- Coordination with the stakeholders - Coordination of Steering Committees - Organization of the wider consultations - Submission of draft reports to stakeholders for comments and feedback	- Knowledge of the UNFCCC reporting requirements including MRV and Enhanced Transparency Framework (ETF) - Capacity to coordinate and facilitate the stakeholder consultations
CCPIU	- Overall supervision of GHG inventory development - Management of contracts and delivery of GHG inventory - Collaboration with various stakeholders - Identification of necessary resources to improve the inventory	- Technical and administrative expertise, - Technical knowledge of the UNFCCC reporting requirements and IPCC methodologies - Capacity to coordinate and lead the process

	- Undertake ICA process	
Data providers	- Collecting GHG inventory related sectorial data and analysis - Timely delivery of data in appropriate format - Providing the review and recommendation on the inventory report - Communication with a lead institution/GHG inventory expert	- Understanding of UNFCCC reporting guidelines, including MRV and ETF, and IPCC methodologies - Technical skills to analyze, process and archive data
Independent entity/individual	- Conducting quality assurance (QA) activities by reviewing the reports, estimation methods, activity data, emission factors, and other items in national inventory	- Technical skills to review the GHG inventory - Technical knowledge of the UNFCCC reporting requirements, including MRV and ETF, and IPCC methodologies
GHG inventory team	- Coordination with lead entity to prepare the GHG inventory - Scheduling of tasks and responsibilities - Collecting data, estimating GHG emission, inventory management, planning, improvement - Undertake research, data collection, calculations, drafting, QC, archiving, and documentation - Data analysis, processing and reporting - Checking the transparency, accuracy, comparability, completeness, and consistency data and methods - Identification of areas to improve GHG inventory data quality - Coordinate with other sector experts to identify and resolve cross-sectoral issues - Conduct QC activities and crosscheck data - Overall QA/QC coordination and/or overall data and document management - Conduct key category analysis, uncertainty analysis and identify trends - Combine sector experts' work into a cohesive inventory product - Facilitate the international consultation and analysis (ICA) - Communication of GHG inventory results to national statistics for publication	- Technical knowledge of the UNFCCC reporting requirements, including MRV and ETF - Technical expertise in IPCC methodologies and software - Technical knowledge of inventory sectors - Technical skills to analyze, process and archive data - Skills in report writing

1.2.2 Overview of inventory planning, preparation and management

Currently the preparation of national GHG inventory is centralized and is being compiled at CCPIU under the CCRCC, MET. The main source of activity data is the National Statistics Office (NSO) of Mongolia and relevant institutions shown above in Figure 1-1. Additional statistics from international sources were used such as International Energy Agency (IEA), Food and Agriculture Organization

(FAO) and World Bank (WB). Some expert assumptions were made for unavailable activity data in order to complete the time series.

Table 1-2 provides more detailed information about the current preparation process of the national GHG inventory. The actual task of national GHG emissions and removals estimation, writing and compiling the national inventory report is conducted by four sectoral experts, include: (1) Energy, (2) IPPU, (3) Agriculture and Waste and (4) LULUCF sector experts. These four experts facilitate activities such as stakeholder consultations, cooperation with relevant ministries, agencies and organizations, for the preparation of national GHG inventory and compilation of supplementary information. The GHG inventory system is not yet institutionalized given the fact that collaboration and data sharing with some stakeholders are facilitated by the memorandum of understanding (MOU).

Table 1-2: Activities and responsibilities of each entity involved in the GHG inventory preparation process

Phase	*Activities*	*Responsible entities*	*Description*
Measurement & Reporting	Review of previous GHG inventories	CCPIU	- Reviews previous inventory against recommendations provided by external consultants
	Gather activity data, emission factors and coefficients	CCPIU and Relevant entities	- Updates the activity and input data taking into consideration data gaps and areas needed improvement identified in previous GHG inventories - Identify the major sectors and institutions holding data and information required for GHG inventory - Discuss, agree and sign MOU with line entities for the data request from relevant ministries, agencies and organizations - Collecting information required for GHG inventory
	Prepare initial estimates and draft report	CCPIU	- Conduct sectorial and national GHG estimation - Prepare draft of the National Inventory Report (NIR)
	Expert and interagency review	CCPIU & Relevant entities	- Organise review and validation workshops with relevant ministries, agencies and organizations - Confirm data provided for the preparation of the inventory
	Implementation of IPCC GHG inventory guidance	CCPIU	- Implements IPCC GHG inventory guidance
Verification	Internal (QC)/External Review (QA)	CCPIU and external consultants	- Verification of the drafts of sectorial NIR - Preparation of the final draft of the NIR
Approval & Deliberation	Approval	MET	- Approval of the national GHG inventory
	Submission	MET and NFP for the UNFCCC	- Submission of NCs/BURs and NIR to UNFCCC secretariat
Publication	Archiving and publication	CCPIU	- Archiving of the relevant data and documentations - Publishing and distributing the national GHG inventory to the public

1.2.3 Quality assurance and Quality control (QA/QC) and verification plan

Quality assurance and quality control (QA/QC) activities on the inventory are undertaken within the framework of this QA/QC plan. The overall aim of QA/QC plan is to maintain and improve the quality in all stages of the inventory work. The QA/QC procedures represent the main instrument for continuous improvement in subsequent inventory cycles. The QA/QC plan guides the process of ensuring inventory quality by describing data and methodology checks, developing processes governing peer review and public comments, and developing guidance on conducting an analysis of the uncertainty surrounding the emission estimates. The QA/QC procedures also include feedback loops and provide for corrective actions that are designed to improve the inventory estimates over time. Sector specific QA/QC plan is based on the general QA/QC rules and activities in specific categories.

In accordance with 2006 IPCC GLs, Volume 1, Chapter 6, the QC has been conducted within the inventory team. The sector specific QC activities were performed during the GHG emissions estimation such as cross-checking several sources for the data, if available, and check accuracy of data inputs into the software including the QC for the EFs and other parameters as well.

The main source of activity data of GHG emissions estimation is the National Statistics Office of Mongolia (NSO). Generally, the NSO collects and consolidates data from organizations/institutions and producers by questionnaires at national level. For the QC/QA, it has done cross-checks of activity data provided by the NSO and institutions that provided the data to NSO. Special data sheets were prepared to collect data from relevant government and private organizations/institutions in order to compare and ensure with data from NSO.

In some cases, data from NSO differed from the data directly provided by questioned organizations/institutions. By the 2006 IPCC GLs recommendation, if there are available several sources of the activity data, it's a good practice to follow the data provided from national statistics, thus, NSO data was used for the inventory where it is needed. If needed, focus group meetings were organized to get agreements on main assumptions made for calculations.

Through the GCP/MON/016/CBT project, the general QA/QC plan for GHG Inventory for AFOLU sector of Mongolia was developed and it has been reviewed by the national GHG Inventory experts.

1.3 Brief general description of methodologies and data sources

Emissions of GHGs from various source and sink categories have been estimated accordance with the 2006 IPCC GLs methods. The Tier 1 IPCC method was applied in general, but also the Tier 2 method was applied for some subcategories of the energy and LULUCF sectors.

1.3.1 Methods of estimation

The methodology for Mongolia's GHG inventory has seen some improvements towards a combination of Tier 1 and Tier 2 estimation methods of the 2006 IPCC GLs. An overview of the methods and EFs applied for the calculations of the emissions is presented in Table 1-3.

Table 1-3: Applied methods and EFs in GHG inventory

Source and Sink Categories		*CO_2*		*CH_4*		*N_2O*		*HFCs*	
		Method	*EF*	*Method*	*EF*	*Method*	*EF*	*Method*	*EF*
1.	Energy	T1, T2	D, CS	T1	D	T1	D	-	-
1.A	Fuel Combustion	T1, T2	D, CS	T1	D	T1	D	-	-
1.A.1	Energy Industries	T1, T2	D, CS	T1	D	T1	D	-	-
1.A.2	Manufacturing Industries and Construction	T1, T2	D, CS	T1	D	T1	D	-	-
1.A.3	Transport	T1	D	T1	D	T1	D	-	-
1.A.4	Other Sectors	T1	D	T1	D	T1	D	-	-
1.A.5	Non-Specified	T1	D	T1	D	T1	D	-	-
1.B	Fugitive emissions	T1	D	T1	D	-	-	-	-
1.B.1	Solid Fuels		-	T1	D	-	-	-	-
1.B.2	Oil and Natural Gas	T1	D	T1	D	T1	D	-	-
1.B.3	Other emissions from Energy Production	NO	NO	NO	NO	NO	NO	-	-
2.	Industrial Processes and	T1	D	-	-	-	-	-	-

	Product Use								
2.A	Mineral Industry	T1	D	-	-	-	-	-	-
2.B	Chemical Industry	NO	NO	-	-	NO	NO	-	-
2.C	Metal Industry	T1	D	NE	NE	-	-	-	-
2.C.1	Iron and Steel Production	T1	D	NO	NO	-	-	-	-
2.D	Non-Energy Products from Fuels and Solvents	T1	D	-	-	-	-	NO	NO
2.E	Electronic Industry	-	-	-	-	-	-	NO	NO
2.F	Product Uses as Substitutes for Ozone Depleting Substances	-	-	-	-	-	-	T1	D
2.G	Other Product Manufacture and Use	NO	NO	NO	NO	NO	NO	-	-
2.H	Other	NO	NO	NO	NO	NO	NO	-	-
3.	Agriculture	-	-	T1	D	-	-	-	-
3.A	Livestock	-	-	T1	D	-	-	-	-
3.A.1	Enteric Fermentation	-	-	T1	D	-	-	-	-
3.A.2	Manure Management	-	-	T1	D	-	-	-	-
3.B	Land	-	-	T1	D	-	-	-	-
3.B.1	Forest land	T1, T2	D, CS	IE, NE	IE, NE	IE, NE	IE, NE	-	-
3.B.2	Cropland	-	-	NE	NE	NE	NE	-	-
3.B.3	Grassland	T1	D	IE, NO	IE, NO	IE, NO	IE, NO	-	-
3.B.4	Wetlands	-	-	-	-	NE	NE	-	-
3.B.5	Settlements	-	-	-	-	-	-	-	-
3.B.6	Other land	NE	NE	-	-	-	-	-	-
3.C	Aggregate sources and non-CO_2 emissions sources on land	-	-	-	-	T1	D	-	-
3.D.1	Harvested Wood Products	T1	D	-	-	-	-	-	-
4.	Waste	-	-	T1/T2	D	NO	NO	-	-
4.A	Solid Waste Disposal	-	-	T1/T2	D	NO	NO	-	-
4.B	Biological Treatment of Solid Wastes	-	-	NE	NE	NE	NE	-	-
4.C	Incineration and Open Burning of Waste	-	-	NO	NO	NO	NO	-	-
4.D	Wastewater Treatment and Discharge	-	-	T1	D	T1	D	-	-
4.E	Other	-	-	NO	NO	NO	NO	-	-

Key: EF=Emission Factor, CS=Country Specific, NE=Not Estimated, NO=Not Occurring, D=Default IPCC methodology and Emission Factor, T1, T2=Levels of Tiers, IE- Included Elsewhere

1.3.2 Data sources

Mongolia’s GHG inventory has been prepared using data from a combination of sources from national and international institutions. The main source of activity data are official statistics of Mongolia. According to recommendation of the 2006 IPCC GLs it’s preferred to use data from national statistics. In cases where the required data was not available, the data from international sources such as IEA, FAO, WB and certain assumptions were used.

MET signed the Memorandum of understanding (MOU) with NSO, the Ministry of Energy (MOE), Ministry of Construction and Urban Development (MCUD), the Ministry of Food, Agriculture and Light Industry (MOFALI), the Ministry of Road and Transport Development (MRTD), the Ministry of Mining and Heavy Industry (MMHI) and the Municipality of Ulaanbaatar City. The sectorial experts from CCPIU collected data and prepared the estimates for the national GHG inventory. The data sources for each sector are described in Table 1-4.

Table 1-4: List of important sources for GHG inventory preparation

Sectors	*Activity data sources*
1. Energy	National Statistics Office (NSO)-statistical yearbook, www.1212.mn, International Energy Agency (IEA) statistics, ministries: Ministry of Road and Transport Development (MRTD), institutions: Civil Aviation Authority of Mongolia (MCAA), Ulaanbaatar Railway Joint Stock Company, Mineral Resources and Petroleum Authority (MRPAM)
2. Industrial processes and product use	NSO-statistical yearbook, www.1212.mn, MOFALI, MMHI, National Ozone Authority (NOA)
3. Agriculture	NSO-statistical yearbook, www.1212.mn, MOFALI – Statistical yearbook of agriculture, FAOSTAT www.fao.org/faostat/en/**,** Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE)
4. LULUCF	NSO-statistical yearbook, www.1212.mn, Agency for Land Adminstration and Management, Geodesy and Cartography (ALAMGAC), FAOSTAT www.fao.org/faostat/en/**,** Forest Research and Development Center (FRDC), www.forest-atlas.mn, IRIMHE
5. Waste	NSO-statistical yearbook, www.1212.mn, World Bank, Mayor's Office of Ulaanbaatar City, MOFALI, MCUD, Water Supply and Sewerage Authority of Ulaanbaatar

1.3.3 Global Warming Potentials (GWPs)

As a non-Annex I Party, Mongolia used the GWPs from the IPCC Second Assessment Report (SAR) 100-year time horizon GWPs (see Table 1-5).

Table 1-5: 100-year time horizon GWPs

Gas		*CO_2 equivalents (CO_2e)*
Direct gases	Carbon dioxide (CO_2)	1
	Methane (CH_4)	21
	Nitrous oxide (N_2O)	310
Fluorinated gases	HFC-23 (CHF_3)	11,700
	HFC-32 (CH_2F_2)	650
	HFC-125 (CHF_2CF_3)	2,800
	HFC-134a (CH_2FCF_3)	1,300
	HFC-152a (CH_3CHF_2)	140
	HFC-143a (CF_3CH_3)	3,800

1.4 Brief description of key categories

Key categories are the categories of emissions/removals, which have a significant influence on the total inventory in terms of the absolute level of emissions (1990 or 2020), the trend of emissions (change between 1990 and 2020). In this report the IPCC Tier 1 method has been used, where categories with cumulative contribution less than 95% are identified as key categories. The results are presented in Table 1-6 and Table 1-7. The identification includes all reported greenhouse gases such as CO_2, CH_4, N_2O, HFCs and the IPCC GHG source categories.

Table 1-6: Summary of key categories for the 2020 level assessment and trend assessment for the period 1990-2020 (including LULUCF)

IPCC Category code	*IPCC Category*	*Greenhouse gas*	*Criteria for identification*
ENERGY			
1.A.1	Energy Industries - Solid Fuels	CO_2	level, trend
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	trend
1.A.3.b	Road Transportation	CO_2	level, trend
1.A.3.e	Other Transportation	CO_2	level
1.A.4	Other Sectors - Solid Fuels	CO_2	level, trend
1.A.5	Non-Specified - Solid Fuels	CO_2	level, trend
1.B.1	Solid Fuels	CH_4	level

INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)			
2.F.1	Refrigeration and Air Conditioning	HFCs	level
AGRICULTURE, FORESTRY, AND OTHER LAND USE (AFOLU)			
3.A.1	Enteric Fermentation	CH_4	level, trend
3.B.1.a	Forest land Remaining Forest land	CO_2	level, trend
3.B.3.b	Land Converted to Grassland	CO_2	trend
3.C.1	Emissions from Biomass Burning	N_2O	trend
3.C.4	Direct N_2O Emissions from Managed Soils	N_2O	level, trend
3.C.5	Indirect N_2O Emissions from Managed Soils	N_2O	level, trend

Table 1-7: Summary of key categories for the 2020 level assessment and trend assessment for the period 1990-2020 (excluding LULUCF)

IPCC Category code	*IPCC Category*	*Greenhouse gas*	*Criteria for identification*
ENERGY			
1.A.1	Energy Industries - Solid Fuels	CO_2	level, trend
1.A.1	Energy Industries - Liquid Fuels	CO_2	level, trend
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	trend
1.A.3.b	Road Transportation	CO_2	level, trend
1.A.3.c	Railways	CO_2	level, trend
1.A.3.e	Other Transportation	CO_2	level, trend
1.A.4	Other Sectors - Solid Fuels	CO_2	level, trend
1.A.4	Other Sectors - Solid Fuels	CH_4	trend
1.A.5	Non-Specified - Solid Fuels	CO_2	level, trend
1.B.1	Solid Fuels	CH_4	level, trend
1.B.2.a	Oil	CH_4	level, trend
INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)			
2.A.1	Cement Production	CO_2	level, trend
2.A.2	Lime Production	CO_2	trend
2.F.1	Refrigeration and Air Conditioning	HFCs	level, trend
AGRICULTURE			
3.A.1	Enteric Fermentation	CH_4	level, trend
3.A.2	Manure Management	CH_4	trend
3.C.1	Emissions from Biomass Burning	CH_4	trend
3.C.1	Emissions from Biomass Burning	N_2O	trend
3.C.4	Direct N_2O Emissions from Managed Soils	N_2O	level, trend
3.C.5	Indirect N_2O Emissions from Managed Soils	N_2O	level, trend

According to the tables above, the most important key categories in energy sector are energy industries and transportation; in IPPU sector are cement production, and refrigeration and air conditioning; and in LULUCF sector is forest land remaining forest land for $CO_{2;}$ and in agriculture sector are the enteric fermentation for CH_4, and managed soils for direct and indirect N_2O. Detailed reporting tables can be found in Annex II.

1.5 General uncertainty evaluation

The uncertainty estimate of the 2020 GHG inventory has been done according to the Tier 1 method presented by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006). Tier 1 method combines the uncertainty in activity rates and EFs, for each source category and GHG, and then aggregates these uncertainties for all source categories and GHGs to obtain the total uncertainty for the inventory.

In many cases uncertainty values have been assigned based on default uncertainty estimates according to the 2006 IPCC GLs or expert judgement because of lack of the information. The uncertainty analysis was done for sectors: energy, IPPU, agriculture, waste and LULUCF sectors considering 1990 as a base year and the assessment has done until 2020. The results of the uncertainty analysis for all sectors have been presented in Annex III.

1.6 General assessment of completeness

1.6.1 Sectors

All sources/removals of direct and indirect GHGs associated with activities occurring in Mongolia covered in GHG inventory included following activities by availability of activity data.

Table 1-8: All sources/removals covered in GHG inventory of Mongolia

Categories		*Gases*
1.	ENERGY	CO_2, CH_4, N_2O
1.A.1.a.i	Electricity generation	CO_2, CH_4, N_2O
1.A.1.a.ii	Combined heat and power generation (CHP)	CO_2, CH_4, N_2O
1.A.2	Manufacturing industries and construction	CO_2, CH_4, N_2O
1.A.3.a.i	International aviation (international bunkers)*****	CO_2, CH_4, N_2O
1.A.3.a.ii	Domestic aviation	CO_2, CH_4, N_2O
1.A.3.b	Road transportation	CO_2, CH_4, N_2O
1.A.3.c	Railways	CO_2, CH_4, N_2O
1.A.3.e.ii	(Other transportation) Off-road	CO_2, CH_4, N_2O
1.A.4.a	(Other sectors) Commercial/institutional	CO_2, CH_4, N_2O
1.A.4.b	Residential	CO_2, CH_4, N_2O
1.A.4.c	Agriculture/forestry/fishing/fish farms	CO_2, CH_4, N_2O
1.A.4.c.i	Stationary	CO_2, CH_4, N_2O
1.A.4.c.ii	Off-road vehicles and other machinery	CO_2, CH_4, N_2O
1.A.5.a	Non-specified (stationary)	CO_2, CH_4, N_2O
1.B.1.a.ii.1	(Surface mining) Mining	CH_4
1.B.1.a.ii.2	Post-mining seam gas emissions	CH_4
1.B.2.a.ii	(Oil) Flaring	CO_2, CH_4, N_2O
1.B.2.a.iii.2	(Oil) Production and upgrading	CO_2, CH_4
Information items**	CO_2 from biomass combustion for energy production	CO_2
2.	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)	CO_2, HFCs
2.A.1	Cement production	CO_2
2.A.2	Lime production	CO_2
2.C.1	Iron and steel production	CO_2
2.D.1	Lubricant use	CO_2
2.F.1.a	Refrigeration and stationary air conditioning	HFC-32 (CHF_3), HFC-125 (CHF_2CF_3), HFC-134a (CH_2FCF_3), HFC-143a (CF_3CH_3)
2.F.1.b	Mobile air conditioning	HFC-134a (CH_2FCF_3)
2.F.2	Foam blowing agents	HFC-152a (CH_3CHF_2)
2.F.3	Fire protection	HFC-125 (CHF_2CF_3)
2.F.4	Aerosols	HFC-134a (CH_2FCF_3)
3.	AGRICULTURE, FORESTRY, AND OTHER LAND USE (AFOLU)	CO_2, CH_4, N_2O, NO_x, CO
3.A.1.a.ii	(Enteric fermentation) Other cattle	CH_4
3.A.1.c	Sheep	CH_4
3.A.1.d	Goats	CH_4

3.A.1.e	Camels	CH_4
3.A.1.f	Horses	CH_4
3.A.1.h	Swine	CH_4
3.A.2.a.ii	(Manure management) Other cattle	CH_4
3.A.2.c	Sheep	CH_4
3.A.2.d	Goats	CH_4
3.A.2.e	Camels	CH_4
3.A.2.f	Horses	CH_4
3.A.2.h	Swine	CH_4
3.A.2.j	Poultry	CH_4
3.B.1.a	(Land) Forest land remaining forest land	CO_2
3.B.1.b	Land converted to forest land	CO_2
3.B.3.b	Land converted to grassland	CO_2
3.B.6.b	Land converted to other land	CO_2
3.C.1.a	Biomass burning in forest lands	CH_4, N_2O, NO_x, CO
3.C.1.c	Biomass burning in grasslands	CH_4, N_2O, NO_x, CO
3.C.4	Direct N_2O emissions from managed soils	N_2O
3.C.5	Indirect N_2O emissions from managed soils	N_2O
3.D.1	Harvested wood products	CO_2
4.	WASTE	CH_4, N_2O
4.A	Solid waste disposal	CH_4
4.D.1	Domestic wastewater treatment and discharge	CH_4, N_2O
4.D.2	Industrial wastewater treatment and discharge	CH_4

** Not included in national total, but reported as memo item.*

*** Not included in national total.*

1.6.2 Gases

Direct gases, namely CO_2, CH_4, N_2O, HFCs and indirect gases (NO_x, CO) have been covered under this inventory. PFCs have not been considered in this inventory due to data unavailability.

1.6.3 Notation keys

NE (not estimated): The following categories have not been estimated due to activity data absence and reported as NE:

- 1.A.1.a.iii – Heat plants
- 1.A.1.b – Petroleum refining
- 1.A.1.c.i – Manufacture of solid fuels
- 1.A.3.d – Water-borne navigation
- 1.A.3.e.i – Pipeline transport
- 1.A.4.c.iii – Fishing (mobile combustion)
- 1.A.5.b – Non-specified (mobile)
- 1.A.5.c – Non-specified (multilateral operations)
- 1.B.1.a.i – Underground mines
- 1.B.1.b – Uncontrolled combustion and burning of coal dumps
- 1.B.1.c – Solid fuel transformation
- 1.B.2.a.i – Oil venting
- 1.B.2.a.iii.1 – Oil exploration
- 1.B.2.a.iii.3 – Oil transport
- 1.B.2.a.iii.4 – Oil refining
- 1.B.2.a.iii.5 – Distribution of oil products
- 1.B.2.b – Natural gas
- 1.B.3 – Other emissions from energy production
- 1.C – Carbon dioxide transport and storage
- 2.D.2 – Paraffin wax use

- 2.D.3 – Solvent use
- 2.G.1.b – Use of electrical equipment
- 2.G.1.c – Disposal of electrical equipment
- 2.G.3 – N_2O from product use
- 3.B.2 – Cropland
- 3.B.3.a – Grassland remaining grassland
- 3.B.4 – Wetlands
- 3.B.5 – Settlements
- 3.B.6.b – Other land remaining other land
- 3.C.1.b – Biomass burning in croplands
- 4.B – Biological treatment of solid waste
- 4.C – Incineration and open burning of waste

NO (not occurring): The highest number of source categories marked as NO is found in IPPU sector, as most of these do not occur in the country.

1.7 Recalculations

Mongolia used the methodologies consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (the 2006 IPCC GLs) same as the initial BUR. In this inventory the most of GHG inventory sectors included updated activity data and also added new category datasets and used newly developed country specific emission factors, thus recalculations were done for entire time series from 1990 to 2020 where it is needed.

CHAPTER 2: TRENDS IN GREENHOUSE GAS (GHG) EMISSIONS/REMOVALS

2.1 Description and interpretation of emission trends for aggregated GHG emissions

The main sources of GHG emissions have been divided into the following sectors: Energy (CRF 1), Industrial Processes and Product Use (IPPU, CRF 2), Agriculture (CRF 3), Land Use, Land Use Change and Forestry (LULUCF, CRF 4) and Waste (CRF 5).

In 2020, total GHG emissions of Mongolia were 43,081.62 Gg CO_2e (excluding LULUCF). This represents a 82.17% increase from the 1990 level of 23,648.79 Gg CO_2e and 6.20% decrease from the 2019 level of 45,927.72 Gg CO_2e. Net GHG emissions in 2020 were 12,909.10 Gg CO_2e (including LULUCF). This represented a 340.02% increase from the 1990 level of -5,378.40 Gg CO_2e and 17.92% decrease from the 2019 level with 15,726.84 Gg CO_2e (Figure 2-1 and Table 2-1).

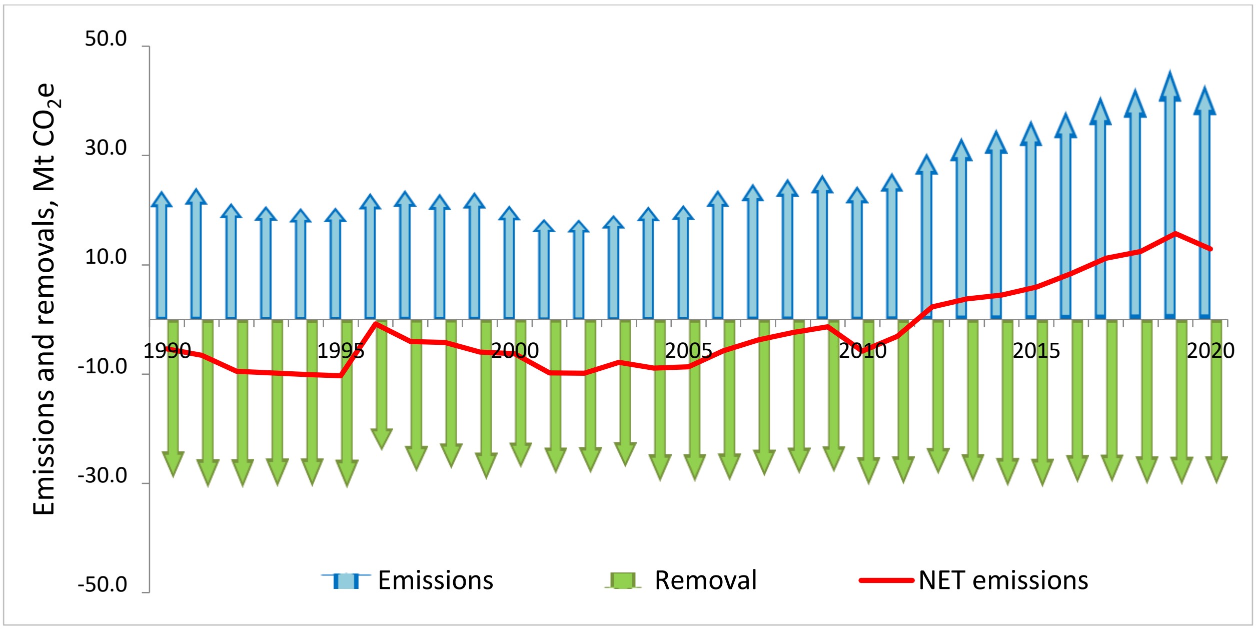

Figure 2-1: Mongolia's total and net GHG emissions and removals, 1990-2020 (Mt CO_2e)

In general, emissions and removals from each sector are show an increase in 2020 compared to the base year and changes are listed in Table 2-1 as anabsolute values and percentage for each GHG inventory sectors.

Table 2-1: Mongolia's GHG emissions/removals by sectors in 1990 and 2020

Sector	*Emissions and removals, (Gg CO_2e)* 1990	*Emissions and removals, (Gg CO_2e)* 2020	*Change from 1990 (Gg CO_2e)*	*Change from 1990 (%)*
Energy	12,086.55	19,292.48	7,205.92	59.62%
IPPU	284.98	1,147.75	862.77	302.75%
Agriculture	11,221.64	22,390.57	11,168.93	99.53%
Waste	55.62	250.82	195.20	350.95%
Total (excluding LULUCF)	23,648.79	43,081.62	19,432.82	82.17%
LULUCF	-29,027.19	-30,172.52	-1,145.33	3.95%
Net total (including LULUCF)	-5,378.40	12,909.10	18,287.49	340.02%

In 2020, GHG emissions from agriculture sector were 22,390.57 Gg CO_2e accounting for 51.97% and from energy sector were 19,292.48 Gg CO_2e for 44.78% of the national total emissions. Emissions from IPPU and Waste sector contributed 1,147.75 Gg CO_2e (2.66%) and 250.82 Gg CO_2e (0.58%), respectively (Figure 2-2).

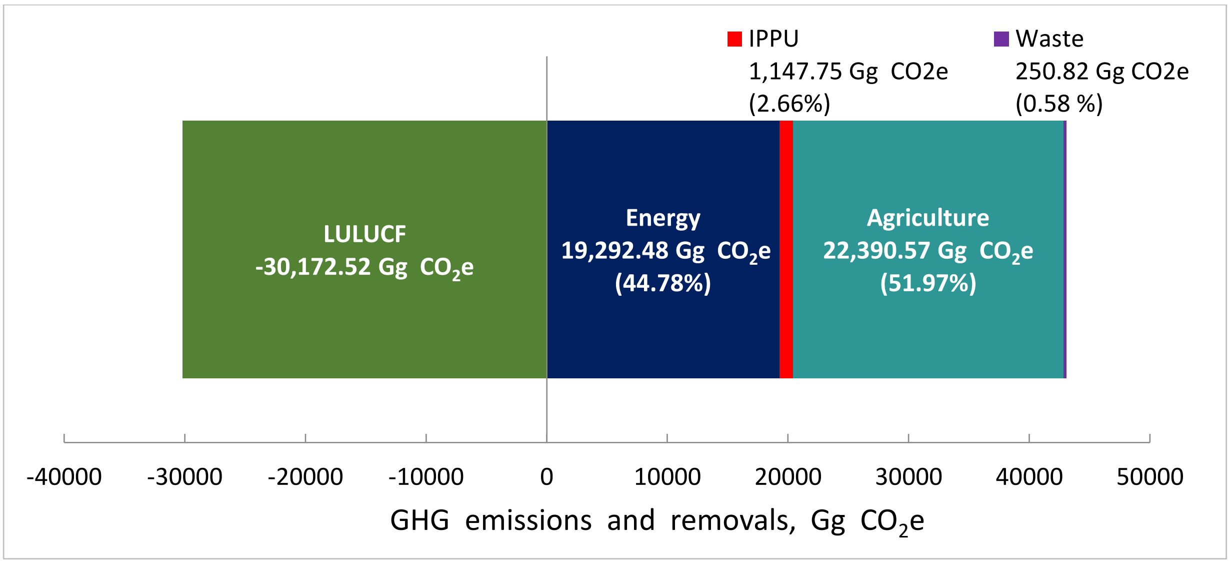

Figure 2-2: The composition of Mongolian GHG emissions by sectors in 2020

Table 2-2 shows an average annual growth rates (AAGR) calculated by 5 years within inventory period, by sectors including national totals. The average annual growth rates of energy sector was decreasing 1990-1995 and IPPU sector was decreasing 1990-1995 and 1996-2000 subsequently, and then growth rate was increasing gradually in energy sector, while in IPPU sector its increased rapidly in 2001-2005. The agriculture sector's growth rate mainly depends on changes in livestock populations. Livestock population was dropped rapidly in 2000-2002 and 2009-2010 due to harsh winter conditions (dzud). In waste sector, the rate is increasing from 1996 to 2020 gradually mostly due to increase urban population and volume of light industry production. Overall, the GHG emissions annual growth changed 2.25% per year from 1990 to 2020 at the national level.

Table 2-2: Average annual growth rates, %

Sector	*1990-1995*	*1996-2000*	*2001-2005*	*2006-2010*	*2011-2015*	*2016-2020*	*1990-2020*
Energy	-6.05	0.13	2.32	6.36	4.23	3.66	1.78
IPPU	-18.38	-4.08	26.20	15.73	9.27	29.16	9.65
Agriculture	0.95	1.53	-0.78	0.48	12.94	2.59	2.95
Waste	0.05	3.49	4.78	5.38	9.41	8.16	5.21
Total (excluding LULUCF)	*-2.65*	*0.61*	*0.38*	*3.31*	*8.44*	*3.45*	*2.25*
LULUCF	1.24	-1.62	1.92	0.47	0.35	-0.33	0.34
Net total (including LULUCF)	*14.95*	*72.37*	*9.39*	*35.27*	*-20.88*	*19.02*	*21.69*

The aggregated GHG emissions and removals by sectors between 1990 and 2020 are shown in Table 2-3 including national total emissions with and excluding LULUCF. The trends of emission and removal from the sectors show different pattern along the time series and main factors affected to trend fluctuation in each sector are written in the later part of this section.

Comparing to the 1990, emissions increase for the energy sector was 59.62%, for the IPPU sector was 302.75%, for the agriculture sector was 99.53%, for the waste sector was 350.95% and removal for the LULUCF sector was 3.95% in 2020.

In 2020 the energy sector emission decreased by 9.79%, the IPPU sector emission increased by 12.66%, the agriculture sector emission decreased by 3.85%, the waste sector emission increased by 7.06% and the LULUCF sector emission decreased by 0.09% compared to 2019.

Table 2-3: The aggregated GHG emissions and removals by sectors, Gg CO_2e

Year	*Energy*	*IPPU*	*Agriculture*	*Waste*	*LULUCF*	*Total (excl. LULUCF)*	*Total (incl. LULUCF)*
1990	12,086.55	284.98	11,221.64	55.62	-29,027.19	23,648.79	-5,378.40
1991	12,218.09	159.92	11,779.02	56.18	-30,777.08	24,213.22	-6,563.86
1992	10,589.40	116.78	10,552.74	54.96	-30,796.13	21,313.88	-9,482.24
1993	10,062.97	80.92	10,588.77	53.66	-30,583.27	20,786.32	-9,796.96
1994	8,751.24	90.79	11,574.18	54.00	-30,565.82	20,470.21	-10,095.61
1995	8,752.15	88.50	11,638.09	55.71	-30,820.64	20,534.44	-10,286.19
1996	8,466.61	90.03	14,556.30	56.56	-23,973.92	23,169.49	-804.42
1997	8,306.43	94.96	15,300.84	58.27	-27,806.97	23,760.49	-4,046.48
1998	8,339.22	92.56	14,639.94	58.57	-27,328.36	23,130.29	-4,198.07
1999	8,385.13	85.84	14,836.47	62.71	-29,321.59	23,370.14	-5,951.44
2000	8,792.39	70.55	11,933.07	66.03	-27,139.37	20,862.04	-6,277.33
2001	8,786.65	55.15	9,523.69	68.45	-28,193.79	18,433.94	-9,759.85
2002	9,398.39	101.84	8,727.06	74.16	-28,132.70	18,301.45	-9,831.25
2003	9,119.37	108.38	9,834.85	76.51	-26,968.87	19,139.11	-7,829.77
2004	9,370.65	55.48	11,232.86	79.03	-29,624.81	20,738.03	-8,886.78
2005	9,833.17	116.83	10,977.51	83.32	-29,684.24	21,010.83	-8,673.41
2006	11,039.76	114.37	12,493.57	87.74	-29,450.74	23,735.44	-5,715.30
2007	11,715.13	123.37	13,019.70	92.25	-28,676.81	24,950.45	-3,726.37
2008	11,836.39	176.51	13,707.12	97.65	-28,205.77	25,817.67	-2,388.09
2009	12,333.01	160.31	13,952.16	103.10	-27,917.77	26,548.57	-1,369.20
2010	13,344.88	222.85	10,786.05	108.25	-30,265.24	24,462.03	-5,803.21
2011	14,308.90	289.13	12,264.68	122.13	-30,115.90	26,984.84	-3,130.78
2012	15,637.24	302.13	14,472.57	137.79	-28,257.61	30,549.72	2,292.12
2013	16,942.32	264.32	16,032.15	148.16	-29,648.23	33,386.95	3,738.71
2014	16,902.95	339.28	17,513.60	159.90	-30,466.11	34,915.74	4,449.63
2015	16,313.23	326.58	19,787.87	169.46	-30,691.25	36,597.14	5,905.89
2016	16,920.24	422.96	20,707.36	183.13	-29,852.24	38,233.68	8,381.44
2017	18,333.25	630.67	21,784.24	198.54	-29,743.29	40,946.70	11,203.41
2018	19,813.99	841.88	21,669.69	218.66	-30,087.02	42,544.22	12,457.19
2019	21,386.93	1,018.81	23,287.71	234.28	-30,200.88	45,927.72	15,726.84
2020	19,292.48	1,147.75	22,390.57	250.82	-30,172.52	43,081.62	12,909.10
Diff. % 1990/ 2020	59.62	302.75	99.53	350.95	3.95	82.17	340.02
Diff. % 2019/ 2020	-9.79	12.66	-3.85	7.06	-0.09	-6.20	-17.92

Note: Totals of columns not consistent due to rounding.

The agriculture and energy sectors are major sources for GHG emissions for the entire time series. However, relative percentages of the sectors to national total varied depending on the socio-economic and climatic factors such as an increasing energy demand in energy sector and increased frequency of severe weather in agriculture sector. Figure 2-3 demonstrated the contribution of emissions from all sectors with rest to the Mongolia's total emissions for the period of 1990-2020.

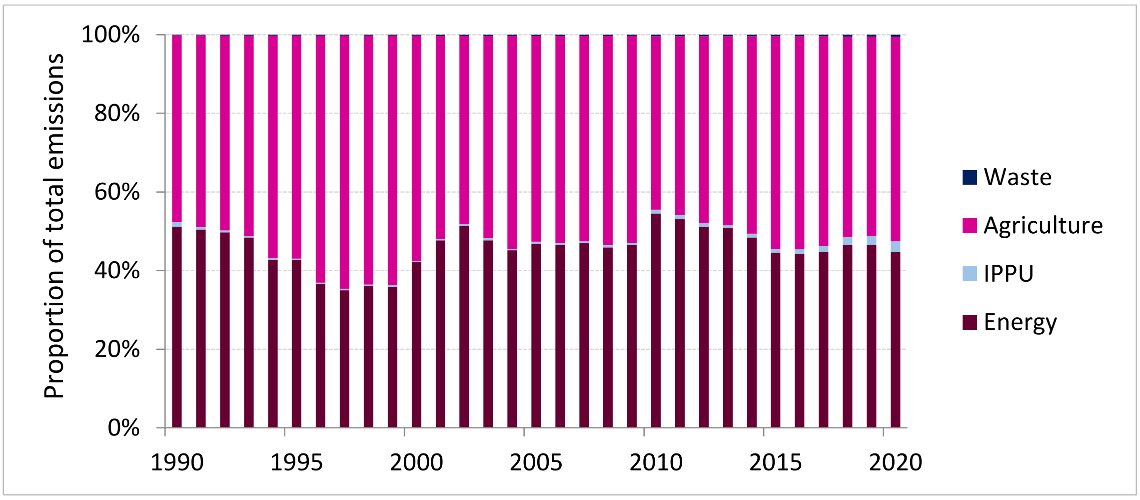

Figure 2-3: The contribution of sectors to Mongolia's total emissions for the period 1990-2020

2.2 Description and interpretation of emission trends sectors/categories

2.2.1 Energy

In 2020, the energy sector accounted for 44.78% (19,292.48 Gg CO_2e) of total national direct GHG emissions (excluding LULUCF), being the second major source of GHG emissions after the energy sector in the country. The GHG emissions fluctuate in the latest years mainly due to economic trend, the energy supply structure and climate conditions. Total emissions in energy sector in 2020 increased by 56.92% compared to the base year 1990. A large part of emissions in energy sector comes from energy industries (electricity generation, electricity and heat production in CHPs) source category (57.51%) in 2020. The emissions from energy industries increased by 73.14% compared to 1990 (Figure 2-4). One of the main factors affecting the GHG emissions from energy industries source category is the increasing energy demand, i.e., increase in housing and energy consumption associated with population growth and migration from rural to urban areas. To reduce the GHG emissions from this source category, energy efficiency in

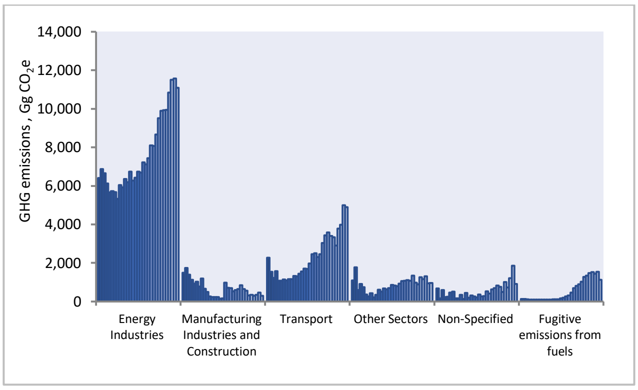

Figure 2-4: Trends in energy sector by categories, 1990-2020

power and heat generation, in industries and in buildings should be improved.

2.2.2 Agriculture

The agriculture sector is the most significant source of the GHG emissions with 51.97% (22,390.57 Gg CO_2e) share of the national total emissions (excluding LULUCF) in 2020. Total emissions in agriculture sector in 2020 increased by 99.53% compared to the base year 1990; in particular, due to increasing the number of domestic livestock which increased 25.8 million in 1990 to 67.1 million in 2020 (Figure 2-5). Emission reduction between 1999-2002 and 2009-2010 caused by livestock loss during the natural disaster. Within the agriculture sector, enteric fermentation contributes the highest to the GHG emissions with 56.90% followed by aggregated sources and non-CO_2 emissions sources on land (41.60%) and manure management with 1.49%.

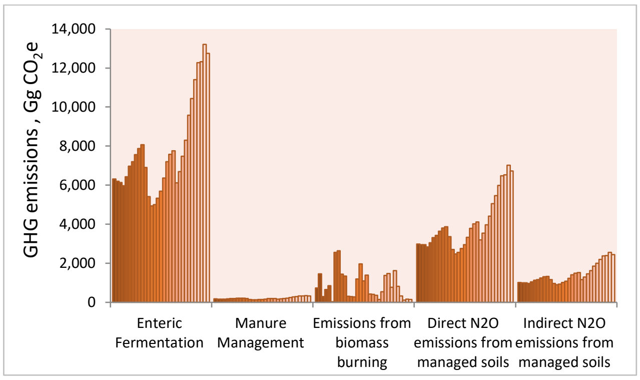

Figure 2-5: Trends in agriculture sector by categories, 1990-2020

2.2.3 Industrial Processes and Product Use (IPPU)

The Industrial Processes and Product Use (IPPU) sector contributes 2.66% (1,147.75 Gg CO_2e) of the national total GHG emissions (excluding LULUCF) in 2020. The total GHG emissions of IPPU sector in 2020 increased by 302.75% compared to the base year 1990. The emission fluctuations in IPPU sectors are linked with the economic situation of the country. The GHG emissions increased in 2020 by 12.66% compared to 2019. The main contributor to the total emissions from IPPU sector is the mineral industry (cement and lime production) and it represents 50.11% of emissions. The cement and lime are the important ingredients for the building materials production. The building material industry is growing in parallel with the population and the economy (Figure 2-6).

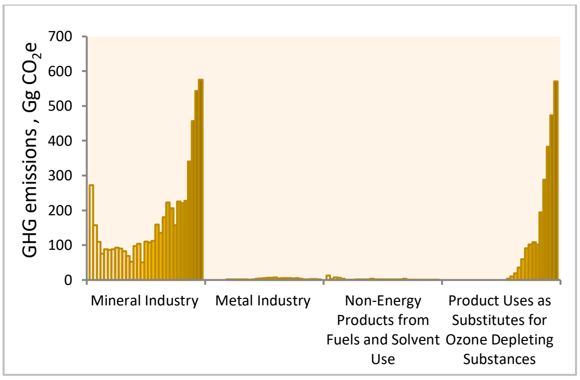

Figure 2-6: Trends in IPPU sector by categories, 1990-2020

2.2.4 Waste

The waste sector is the insignificant source of the GHG emissions contributes only 0.58% (250.82 Gg CO_2e) to national total (excluding LULUCF) in 2020. Total aggregated emissions from the waste sector have increased by 195.20 Gg CO_2e (350.95%) from the 1990 level of 55.62 Gg CO_2e. The total CO_2 equivalent emissions from waste sector in 2020 increased by 7.06% compared to 2019 (Figure 2-7). The emissions from solid waste disposal sites (SWDS) contribute 62.05%, domestic wastewater treatment and discharge 29.65% and industrial wastewater treatment and discharge 8.30% to waste sector's total emissions in 2020. The emissions from waste sector have increased continuously year after year in relation to the population growth especially in urban areas, operational and management changes at some solid waste disposal sites, and the country's poor state of domestic wastewater treatment facilities.

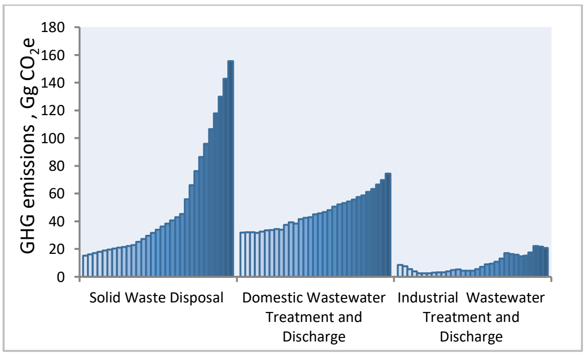

Figure 2-7: Trends in waste sector by categories, 1990-2020

2.2.5 Land use, land use change and forestry

Land Use, Land Use Change and Forestry (LULUCF) is a net sink in Mongolia accounted approximately 50% of net removal of the country's direct GHG emissions. In 2020, the emissions were -30,172.52 Gg CO_2e which was increased by 3.95% compared to 1990 and mainly occurred in the forest land category including forest land remaining forest land and land converted to forest land (Figure 2-8). However, due to lack of activity data and country specific parameters for GHG removals and emissions, emissions from the second largest source, grassland, in Mongolia not included in this report. From 1986 to 2020, a total of 1,037,932 hectares of land area had converted within the IPCC main classifications out of which 64% is occurred in grassland.

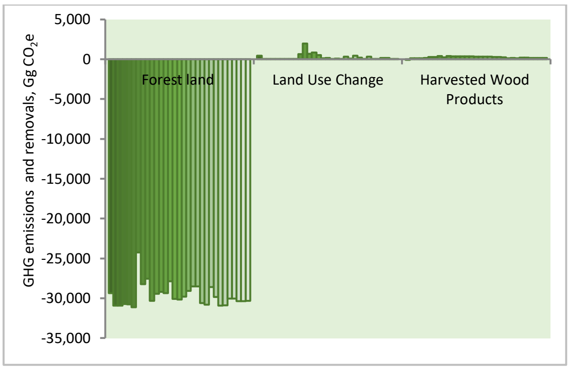

Figure 2-8: Trends in LULUCF sector by categories, 1990-2020

2.3 Description and interpretation of emission trends by gases

The most important GHG in Mongolia is carbon dioxide (CO_2) (excluding LULUCF) accounting 42.40% of national total in 2020, primarily emitted from fuel combustion activities. Second dominant gas is methane (CH_4) which mainly emitted from enteric fermentation process and solid waste disposal contributed 33.82% to national total GHG emissions. Nitrous oxide (N_2O) emitted from agricultural soils contributes 22.46% to national total and HFCs emitted from refrigerator, air conditioning, fire protector, foam blowing equipment utilization contributed the remaining 1.33%. In

Figure 2-9 presented a long-term trend of GHG emissions by gases, CO_2, CH_4 and N_2O and comparisons of emissions between 1990 and 2020 by gases listed in Table 2-4 and more details are available in chapters 2.3.1-2.3.4.

HFCs dataset, mostly emitted from refrigeration and air conditioning equipment, was available since 2012 and the main source is the "*Report for HFCs inventory and identification of opportunities for introduction of low-GWP alternatives in Mongolia*". More details discussed in Chapter 4.8: Product uses as substitutes for ozone depleting substances (2.F).

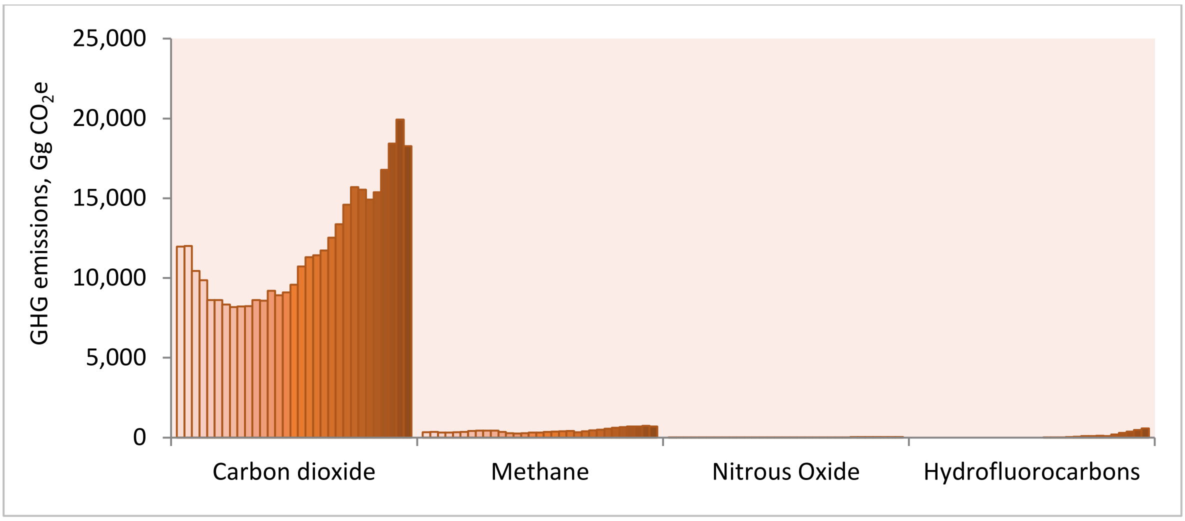

Figure 2-9: Emission trend of CO_2, CH_4 and N_2O from 1990 to 2020

Table 2-4: Mongolia's total GHG emissions by gases in 1990 and 2020

Direct GHGs	*Emissions, (Gg CO_2e)*		*Change from 1990 (Gg CO_2e)*	*Change from 1990 (%)*
	1990	*2020*		
CO_2	11,970.55	18,265.66	6,295.11	52.59
CH_4	7,076.91	14,570.44	7,493.53	105.89
N_2O	4,601.33	9,674.22	5,072.89	110.25
HFCs	NA	571.30	NA	NA
Total	23,648.79	43,081.62	19,432.83	82.17

Note: Total emissions exclude removals from the LULUCF sector. The per cent change for hydro fluorocarbons is not applicable (NA) because the emissions estimation of hydrofluorocarbons was not conducted for 1990.

2.3.1 Carbon dioxide (CO_2)

The CO_2 emission from all sectors (excluding LULUCF) increased from 11,970.55 Gg CO_2e in 1990 to 18,265.66 Gg CO_2e in 2020, by 52.59%, mainly due to enhanced activities from energy sector.

Main source of CO_2 emissions in Mongolia due to fossil fuel combustion and emissions from this activity varied from 11,685.58 Gg in 1990 to 17,656.40 Gg in 2020, increasing by 51.10%.

Table 2-5: Mongolia's total CO_2 emissions by subsectors

Categories	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*Share, %*
1 - Energy	11,685.58	8,537.47	8,542.54	9,465.65	12,347.68	14,694.45	17,689.21	96.84%
1.A - Fuel Combustion Activities	*11,685.58*	*8,537.47*	*8,542.02*	*9,464.08*	*12,330.24*	*14,624.40*	*17,656.40*	*96.66%*
1.B - Fugitive			*0.53*	*1.57*	*17.44*	*70.05*	*32.81*	*0.18%*

emissions from fuels								
2 - Industrial Processes and Product Use	284.98	88.50	70.55	116.83	187.18	224.60	576.45	3.16%
2.A - Mineral Industry	*272.08*	*86.64*	*68.28*	*110.36*	*180.20*	*220.49*	*575.18*	*3.15%*
2.C - Metal Industry		*1.25*	*1.04*	*5.24*	*5.14*	*3.50*	*1.22*	*0.01%*
2.D - Non-Energy Products from Fuels and Solvent Use	*12.89*	*0.62*	*1.23*	*1.23*	*1.85*	*0.62*	*0.04*	*0.00%*
3 - Agriculture, Forestry, and Other Land Use	-29,027.19	-30,820.64	-27,139.37	-29,684.24	-30,265.24	-30,691.25	-30,172.52	100.00%
3.B - Land	*-28,944.49*	*-31,117.10*	*-27,477.48*	*-30,019.76*	*-30,533.45*	*-30,888.38*	*-30,332.02*	*100.53%*
3.D - Other	*-82.70*	*296.46*	*338.11*	*335.52*	*268.21*	*197.13*	*159.50*	*-0.53%*
Total National Emissions (Gg CO_2)	11,970.55	8,625.97	8,613.10	9,582.48	12,534.86	14,919.05	18,265.66	100.00%
Total National Removals (Gg CO_2)	-29,027.19	-30,820.64	-27,139.37	-29,684.24	-30,265.24	-30,691.25	-30,172.52	100.00%
Total National Emissions and Removals (Gg CO_2)	-17,056.64	-22,194.67	-18,526.27	-20,101.75	-17,730.38	-15,772.20	-11,906.87	100.00%

2.3.2 Methane (CH_4)

CH_4 emissions increased from 337.00 to 693.83 Gg CO_2e with a 105.89% change from 1990 to 2020, respectively. Main sources of CH_4 emissions are enteric fermentation in agriculture sector, fugitive emissions from coal mining and handling, and solid waste disposal on land (landfills).

Table 2-6: Mongolia's total CH_4 emissions by subsectors

Categories	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*Share, %*
1 - Energy	10.47	5.89	6.72	10.61	37.09	65.20	57.16	8.24%
1.A - Fuel Combustion Activities	*4.24*	*1.52*	*1.89*	*3.13*	*4.76*	*4.19*	*4.67*	*0.67%*
1.B - Fugitive emissions from fuels	*6.23*	*4.37*	*4.83*	*7.48*	*32.33*	*61.00*	*52.50*	*7.57%*
3 - Agriculture, Forestry, and Other Land Use	324.46	341.61	345.44	301.57	302.03	542.82	626.02	90.23%
3.A - Livestock	*308.85*	*340.73*	*338.04*	*278.58*	*298.72*	*509.64*	*622.63*	*89.74%*
3.C - Aggregate sources and non-CO_2 emissions sources on land	*15.61*	*0.88*	*7.40*	*22.98*	*3.30*	*33.18*	*3.40*	*0.49%*
4 - Waste	2.06	2.01	2.39	3.16	4.29	7.07	10.65	1.53%
4.A - Solid Waste Disposal	*0.73*	*0.93*	*1.09*	*1.62*	*2.16*	*4.57*	*7.41*	*1.07%*
4.D - Wastewater Treatment and Discharge	*1.33*	*1.08*	*1.30*	*1.54*	*2.13*	*2.50*	*3.23*	*0.47%*
Total National Emissions (Gg CH_4)	337.00	349.52	354.55	315.34	343.40	615.08	693.83	100.00%

2.3.3 Nitrous oxide (N_2O)

N_2O emissions increased from 14.84 to 31.21 for the period of 1990-2020, a 110.25% increase over 30 years. Main sources include direct N_2O emissions from managed soils; indirect N_2O emissions from managed soils; energy industries; manufacturing industries and construction; transport and residential sectors, and domestic wastewater treatment and discharge (Table 2-7).

Table 2-7: Mongolia's total N_2O emissions by subsectors

Categories	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*Share, %*
1 - Energy	0.58	0.29	0.35	0.47	0.70	0.81	1.30	4.16%

1.A - Fuel Combustion Activities	*0.58*	*0.29*	*0.35*	*0.47*	*0.70*	*0.80*	*1.30*	*4.16%*
3 - Agriculture, Forestry, and Other Land Use	14.22	14.40	15.09	14.98	14.33	27.06	29.82	95.55%
3.C - Aggregate sources and non-CO2 emissions sources on land	*14.22*	*14.40*	*15.09*	*14.98*	*14.33*	*27.06*	*29.82*	*95.55%*
4 - Waste	0.04	0.04	0.05	0.05	0.06	0.07	0.09	0.28%
4.D - Wastewater Treatment and Discharge	*0.04*	*0.04*	*0.05*	*0.05*	*0.06*	*0.07*	*0.09*	*0.28%*
Total National Emissions (Gg N_2O)	14.84	14.74	15.49	15.50	15.10	27.93	31.21	100.00%

2.3.4 Hydrofluorocarbons (HFCs)

The activity data for the estimation of HFCs emissions were available only from 2012 to 2020. Therefore the emissions have been estimated only for last few years. Since the HFCs emissions are directly related to the consumption of applications which include fluorinated substitutes, the emissions increasing with the growing consumption of applications. For the emissions estimation from HFCs was used Tier 1 method of 2006 IPCC GLs which is using the default emission factors. The Tier 1 method then back-calculates the development of banks of a refrigerant from the current reporting year to the year of its introduction. The year of introduction for HFC-134a (mobile air conditioning) was 2007. Thus the emissions have been calculated for the period 2007-2020 and increased remarkably for this period from 3.10 to 571.30 Gg CO_2e due to growth of imported refrigeration and air conditioning equipment.

Table 2-8: Mongolia's total HFCs emissions by subsectors

Categories	*2007*	*2010*	*2015*	*2020*	*Share, %*
2 - Industrial Processes and Product Use	*3.10*	*35.67*	*101.97*	*571.30*	*100.00*
2.F.1 - Refrigeration and Air Conditioning	-	*35.56*	*100.79*	*569.28*	*99.65*
2.F.2 - Foam Blowing Agents	-	*0.08*	*0.74*	*1.05*	*0.18*
2.F.3 - Fire Protection	-	*0.03*	*0.44*	*0.97*	*0.17*
2.F.4 - Aerosols	-	-	-	-	*0.00*
Total National Emissions (Gg CO_2e)	*3.10*	*35.67*	*101.97*	*571.30*	*100.00*

2.4 Description and interpretation of emission trends for indirect GHGs

NO_x and CO emissions are included in the CRF and the Table 2-9 summarizes indirect gas emissions from the AFOLU sector in 1990 and 2020.

Table 2-9: Mongolia's total emissions by indirect gases for the years 1990 and 2020

Indirect GHG emissions	*Emissions, (Gg CO_2e)*		*Change from 1990 (Gg CO_2e)*	*Change from 1990 (%)*
	1990	*2020*		
NO_x	22.84	3.36	-19.48	-85.29%
CO	422.31	83.58	-338.73	-80.21%

2.4.1 Nitrogen oxides (NO_x)

NO_x emissions emitted from biomass burning in forest land and grassland and it shows a decrease from 22.84 Gg CO_2e to 3.36 Gg CO_2e from 1990 to 2020. NO_x emissions in 2020 were -85.29% below the level of 1990 (Table 2-10).

Table 2-10: Mongolia's NOx total emissions from 1990 to 2020

Categories	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*
Total National Emissions	22.84	0.67	6.92	35.37	3.36	54.89	3.36

3 - Agriculture, Forestry, and Other Land Use	*22.84*	*0.67*	*6.92*	*35.37*	*3.36*	*54.89*	*3.36*
3.C.1 - Emissions from biomass burning (Gg NOx)	*22.84*	*0.67*	*6.92*	*35.37*	*3.36*	*54.89*	*3.36*

2.4.2 Carbon monoxide (CO)

The main source of CO emissions is burning of biomass in forest land and grasslands. The CO emissions decreased from 422.31 Gg in 1990 to 83.58 Gg in 2020 which are resulted from the biomass burning. In 2020 the CO emissions were -80.21% below the level of 1990 (Table 2-11).

Table 2-11: Mongolia's CO total emissions from 1990 to 2020

Categories	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*
Total National Emissions	422.31	20.61	179.89	630.83	81.70	930.54	83.58
3 - Agriculture, Forestry, and Other Land Use	*422.31*	*20.61*	*179.89*	*630.83*	*81.70*	*930.54*	*83.58*
3.C.1 - Emissions from biomass burning (Gg CO)	*422.31*	*20.61*	*179.89*	*630.83*	*81.70*	*930.54*	*83.58*

CHAPTER 3: ENERGY

3.1 Overview of sector

The energy sector of GHG inventory in Mongolia consist of two main source categories: fuel combustion activities (CRF 1.A) and fugitive emissions from fuels (CRF 1.B). The energy sector covers GHG emissions for the period 1990-2020 from following categories: energy industries (1.A.1) including electricity generation, combined heat and power generation and other energy industries; manufacturing industries and construction (1.A.2), transport (1.A.3) including civil aviation, road transportation, railways and other transportation; other sectors (1.A.4) including commercial/institutional, residential and agriculture; non-specified (1.A.5) including stationary combustion; fugitive emissions from fuels (1.B) including surface mining, oil flaring and oil production and upgrading.

The Figure 3-1 shows the share of each subsector of energy sector in Mongolia's total GHG emissions excluding LULUCF sector in the year 2020.

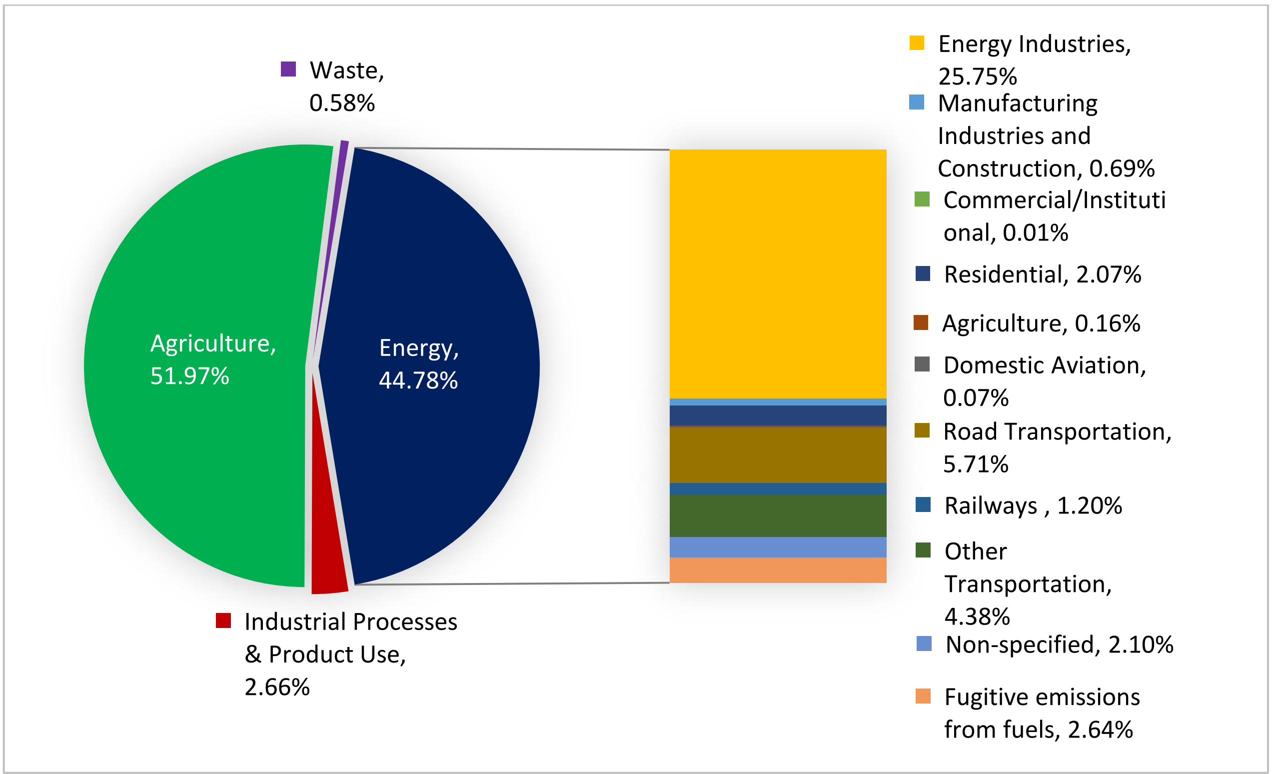

Figure 3-1: Share of each subsector of energy sector in overall national total GHG emissions (excl. LULUCF) in 2020

As of 2020, the energy sector shares 44.78% of the total GHG emissions excluding the LULUCF sector. The most emitter in the energy sector is the energy industries, including electricity generation, combined heat and power generation (CHP) and heat plants. The next largest emitter subsectors are road transportation and other transportation. The other transportation subsector includes the off-road transport in the mining sector.

In Mongolia, the energy sector was the main contributor to overall GHG emissions (excluding LULUCF) with its share of 51.11% and 12,086.55 Gg of CO_2 equivalents (Gg CO_2e) in 1990, but as of 2020 its share was 44.78% and 19,292.48 Gg CO_2e. The decreasing number in percentages of the energy sector sharing does not mean that energy sector emissions are decreasing, but it means the share of other sectors like agriculture, industry and waste are increasing over time series.

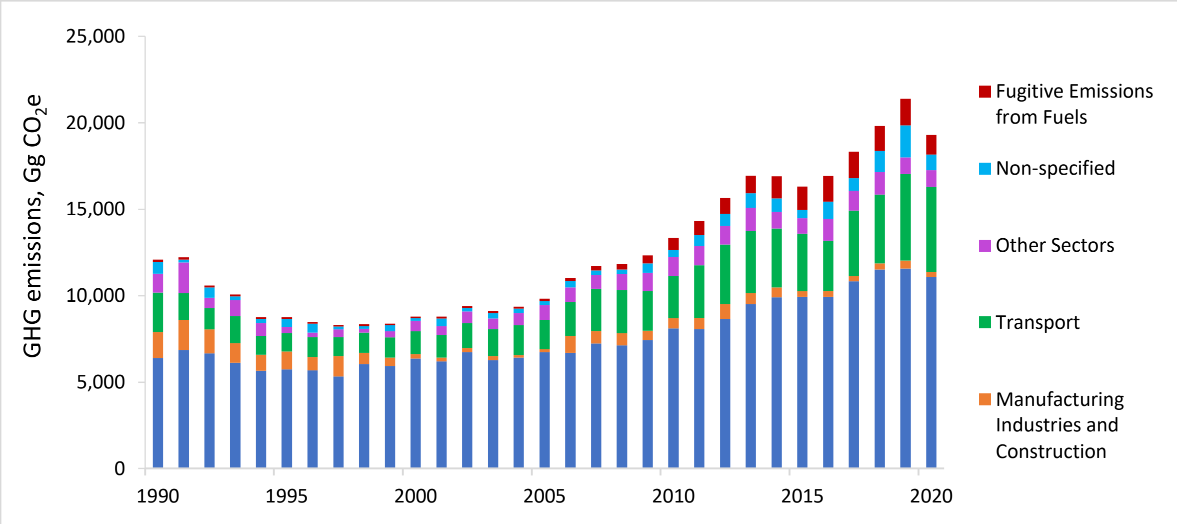

Figure 3-2: Trend in aggregated emissions by source categories within energy sector for the period 1990-2020, Gg CO_2e

The inventory of emissions from fuel combustion includes direct GHG emissions such as CO_2, CH_4, N_2O emissions. The emissions from international bunkers (CO_2, CH_4, N_2O) and CO_2 emission from biomass combustion are included in memo items and not combining into the national total. Figure 3-2 shows the share of GHG emissions by source categories and the trend of GHG emissions by categories in Gg of CO_2 equivalents (CO_2e) within the energy sector.

Considering the energy sector alone as 100%, the energy industries subsector contribute the most percentage to the GHG emissions and next three major contributors are the road transportation, other transportation (which is offroad transport in the mining industry) and fugitive emissions from fuels each with 57.51%, 12.75%, 9.78%, and 5.89%, respectively (see Table 3-1). A long-term trend of the share of energy industries is showed relatively small variation for entire time series, for example from 53.02% in 1990 increased up to 72.35% in 2000, and steadily decreasing to 57.51% in 2020. The share of manufacturing industries and construction source category is slightly increased from 12.36% in 1990 up to 14.42% in 1997 and unsteadily decreasing to 1.54% in 2020. The emissions in the manufacturing industries and construction category, i.e. coal consumption in this category, are falling due to the connection of construction factories to central heating systems and electricity grids, and as well as technical and technological innovations.

Table 3-1: GHG emissions from energy sector by source categories, Gg CO_2e

IPCC categories	Units	1990	1995	2000	2005	2010	2015	2020
Energy industries	Gg	6,408.20	5,734.65	6,361.32	6,740.47	8,102.31	9,934.12	11,095.40
	%	*53.02*	*65.52*	*72.35*	*68.55*	*60.71*	*60.90*	*57.51*
Manufacturing industries and construction	Gg	1,494.38	1,029.55	262.87	168.24	597.94	315.26	297.25
	%	*12.36*	*11.76*	*2.99*	*1.71*	*4.48*	*1.93*	*1.54*
*Transport **	Gg	2,277.86	1,074.46	1,320.03	1,698.12	2,448.87	3,343.24	4,896.88
	%	*18.85*	*12.28*	*15.01*	*17.27*	*18.35*	*20.49*	*25.38*
Domestic aviation	Gg	6.02	32.45	29.26	30.06	25.77	43.42	30.54
	%	*0.05*	*0.37*	*0.33*	*0.31*	*0.19*	*0.27*	*0.16*

Road transportation	Gg	1,275.58	647.67	816.65	953.05	1,196.25	1,727.66	2,460.63
	%	*10.55*	*7.40*	*9.29*	*9.69*	*8.96*	*10.59*	*12.75*
Railways	Gg	327.40	186.71	176.42	217.06	309.95	368.59	518.81
	%	*2.71*	*2.13*	*2.01*	*2.21*	*2.32*	*2.26*	*2.69*
Off-road transportation	Gg	668.85	207.63	297.69	497.95	916.90	1,203.57	1,886.90
	%	*5.53*	*2.37*	*3.39*	*5.06*	*6.87*	*7.38*	*9.78*
*Other sectors***	Gg	1,098.43	361.66	607.83	856.99	1,082.79	882.73	964.08
	%	*9.09*	*4.13*	*6.91*	*8.72*	*8.11*	*5.41*	*5.00*
Commercial/ Institutional	Gg	2.78	124.49	314.00	243.39	7.04	7.40	4.80
	%	*0.02*	*1.42*	*3.57*	*2.48*	*0.05*	*0.05*	*0.03*
Residential	Gg	840.13	188.35	278.33	565.25	1,030.37	828.58	891.26
	%	*6.95*	*2.15*	*3.17*	*5.75*	*7.72*	*5.08*	*4.62*
Agriculture	Gg	255.52	48.83	15.49	48.34	45.37	46.76	68.01
	%	*2.11*	*0.56*	*0.18*	*0.49*	*0.34*	*0.29*	*0.35*
Non-specified	Gg	676.77	460.02	138.42	210.64	416.49	486.45	903.51
	%	*5.60*	*5.26*	*1.57*	*2.14*	*3.12*	*2.98*	*4.68*
Fugitive emissions from fuels (coal, oil)	Gg	130.91	91.80	101.92	158.71	696.47	1,351.43	1,135.36
	%	*1.08*	*1.05*	*1.16*	*1.61*	*5.22*	*8.28*	*5.89*
Solid fuels	Gg	130.91	91.80	94.84	137.47	461.17	406.34	692.75
	%	*1.08*	*1.05*	*1.08*	*1.40*	*3.46*	*2.49*	*3.59*
Oil	Gg	NO	NO	7.09	21.24	235.30	945.09	442.61
	%	*NO*	*NO*	*0.08*	*0.22*	*1.76*	*5.79*	*2.29*
Energy Total	Gg	12,086.55	8,752.15	8,792.39	9,833.17	13,344.88	16,313.23	19,292.48
	%	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*

** Transport sector include domestic aviation, road transportation, railways and off-road transportation subsectors.*
*** Other sectors include commercial/institutional, residential and agriculture/forestry/fishing source categories.*

As of 2020, the share of energy industries (mostly electricity and heat production) in total fuel combustion source category (1.A) is the most highest, namely 57.51%, within the energy sector followed by transport category with 25.38%, and other sectors, including commercial/institutional, residential, agriculture and forestry categories, with 5.00%. The residential category within the other sectors (1.A.4) has the highest share with 92.45% and followed by agriculture/forestry 7.05% and commercial/institutional 0.5% categories in the year of 2020. The residential category represents relatively large area where citizen around the city centers living in the small houses and yurts, not connected to the central heating system and fires the partially improved coal briquettes and raw coal. Nationwide, more households live in houses and yurts without central heating (more than 50%) than those who live in houses and apartments connected to the central heating. The road transportation represents 50.25% and it is the most important key source with one of the highest share on emissions within the transport category. The next important sources of transport category are the off-road transportation and the railways with share of 38.53% and 10.59%, respectively. The domestic aviation has the share of 0.16%, but the international aviation bunkers will be not combined in the national total emissions and reported as memo item with 30.54 Gg CO_2e in 2020.

In addition to fuel combustion, also pollution from small sources of residential heating systems and fugitive methane emissions from solid fuel transmission/transport/distribution significantly contribute to the total GHG emissions. The emissions from energy sector have been increased by 59.62% from 12,086.55 Gg CO_2e in 1990 to 19,292.48 Gg CO_2e in 2020 (Table 3-2).

Table 3-2: GHG emissions from energy sector by source categories, Gg CO_2e

Source categories	*GHGs*	*Emissions (Gg CO_2e)*		*Change from 1990 (Gg CO_2e)*	*Change from 1990 (%)*
		1990	*2020*		
1.A.1 - Energy industries	CO_2, CH_4, N_2O	6,408.20	11,095.40	4,687.20	73.14
1.A.2 - Manufacturing industries and construction	CO_2, CH_4, N_2O	1,494.38	297.25	-1,197.13	-80.11
1.A.3 - Transport	CO_2, CH_4, N_2O	2,277.86	4,896.88	2,619.02	114.98
1.A.4 - Other sectors	CO_2, CH_4, N_2O	1,098.43	964.08	-134.35	-12.23
1.A.5 - Non-specified	CO_2, CH_4, N_2O	676.77	903.51	226.81	33.51
1.B - Fugitive emissions from fuels (coal, oil)	CO_2, CH_4	130.91	1,135.36	1,004.45	767.28
1. Energy Total	CO_2, CH_4, N_2O	12,086.55	19,292.48	7,205.93	59.62

The decrease in emissions from the manufacturing industries and construction category and commercial/institutional subcategory within other sectors is due to the fact that factories are connected to centralized heating system and electricity grids, as well as technical and technological innovations are being carried out.

Table 3-3 shows emissions of source categories within energy sector. It shows the differences between base and end year (1990/2020) of the inventory and the differences between end year and prior year (2019/2020) as well. In this way, the increase or decrease in emissions can be seen for the years compared.

Table 3-3: GHG emissions within energy sector in 1990-2020

Years	*1.A.1 Energy industries*			*1.A.2 Manufacturing industries and construction*	*1.A.3 Transport*			
	1.A.1.a.i Electricity generation	*1.A.1.a.ii Combined heat and power peneration (CHP)*	*1.A.1.c.ii Other energy industries*		*1.A.3.a Civil aviation*	*1.A.3.b Road transportation*	*1.A.3.c Railways*	*1.A.3.e.ii Off-road*
	Gg of CO_2e							
1990	124.64	6,281.03	2.53	1,494.38	6.02	1,275.58	327.40	668.85
1991	90.40	6,778.75	2.53	1,738.05	16.38	836.37	200.64	485.09
1992	55.47	6,603.87	2.76	1,386.98	23.86	743.99	166.83	297.69
1993	96.56	6,023.02	3.00	1,124.45	26.72	718.26	316.73	518.18
1994	44.52	5,609.28	3.00	936.25	31.81	589.41	220.21	238.88
1995	38.69	5,692.97	3.00	1,029.55	32.45	647.67	186.71	207.63
1996	41.09	5,626.25	3.00	781.30	43.74	664.50	216.25	220.49
1997	43.83	5,275.08	3.23	1,196.54	39.28	627.40	190.94	235.19
1998	44.52	5,996.23	3.23	656.02	33.08	728.67	166.32	238.88
1999	54.45	5,874.18	3.23	494.09	25.29	690.57	154.31	292.16
2000	55.47	6,300.77	5.07	262.87	29.26	816.65	176.42	297.69
2001	59.58	6,131.48	5.76	224.53	36.26	794.37	157.19	319.72
2002	65.40	6,669.44	6.45	225.72	32.60	866.33	196.86	350.97
2003	73.62	6,193.81	6.45	228.51	38.01	927.78	198.43	395.08
2004	88.34	6,329.76	6.45	150.26	36.26	989.77	208.87	474.07
2005	92.79	6,641.23	6.45	168.24	30.06	953.05	217.06	497.95
2006	106.15	6,527.46	61.71	977.33	65.85	1,054.82	285.55	569.62
2007	132.86	7,054.33	43.93	717.84	62.35	1,306.74	374.98	712.95
2008	146.56	6,931.33	44.42	702.83	50.26	1,397.10	265.88	786.46
2009	142.44	7,269.86	30.12	523.06	23.38	1,255.82	258.72	764.39
2010	170.86	7,894.75	36.69	597.94	25.77	1,196.25	309.95	916.90

2011	221.54	7,813.50	34.69	649.72	39.92	1,416.29	388.01	1,188.87
2012	245.16	8,381.85	36.86	850.07	57.58	1,656.17	411.36	1,315.62
2013	265.03	9,217.61	31.26	637.44	61.71	1,667.69	441.61	1,422.22
2014	234.89	9,630.66	35.13	570.14	41.67	1,717.83	389.96	1,260.50
2015	224.28	9,684.32	25.53	315.26	43.42	1,727.66	368.59	1,203.57
2016	187.65	9,740.70	13.08	339.11	39.44	1,531.75	321.41	1,006.96
2017	275.74	10,545.18	15.13	294.72	48.76	1,782.17	472.09	1,479.72
2018	290.64	11,198.20	18.91	349.25	64.10	1,885.73	480.81	1,559.68
2019	369.94	11,186.83	18.65	464.66	74.12	2,361.40	582.57	1,985.21
2020	351.62	10,730.08	13.70	297.25	30.54	2,460.63	518.81	1,886.90
Diff % 1990/2020	*182.11*	*70.83*	*441.50*	*-80.11*	*407.31*	*92.90*	*58.46*	*182.11*
Diff % 2019/2020	*-4.95*	*-4.08*	*-26.54*	*-36.03*	*-58.80*	*4.20*	*-10.94*	*-4.95*

Table 3-3 (cont.): GHG emissions within energy sector in 1990-2020

Years	*1.A.4 Other sectors*				*1.A.5 Non-specified*	*1.B Fugitive emissions from fuels*		
	1.A.4.a Commercial/ Institutional	*1.A.4.b Residen-tial*	*1.A.4.c.i Agriculture -Stationary*	*1.A.4.c.ii Agriculture -Off-road vehicles and other machinery*	*1.A.5.a Stationary*	*1.B.1.a Coal mining & handling (surface mining)*	*1.B.2.a.ii Oil - Flaring*	*1.B.2.a.iii.2 Oil production and upgrading*
				Gg of CO_2e				
1990	2.78	840.13	235.29	20.23	676.77	130.91	NO	NO
1991	700.05	907.75	150.00	14.67	168.68	128.71	NO	NO
1992	312.66	175.17	102.91	9.01	593.94	114.26	NO	NO
1993	585.17	217.77	86.67	15.67	228.02	102.74	NO	NO
1994	489.06	183.96	57.25	7.22	246.04	94.35	NO	NO
1995	124.49	188.35	42.54	6.28	460.02	91.80	NO	NO
1996	94.04	141.26	23.44	6.67	511.11	93.47	NO	NO
1997	101.03	316.36	11.70	7.11	168.68	90.06	NO	NO
1998	33.86	154.54	17.52	7.22	161.78	92.50	0.35	4.50
1999	159.07	135.03	48.47	8.84	346.80	90.80	0.57	7.30
2000	314.00	278.33	6.49	9.01	138.42	94.84	0.51	6.57
2001	178.47	317.11	8.33	9.67	442.27	94.03	0.57	7.30
2002	78.86	574.76	14.42	10.62	189.61	101.41	1.08	13.86
2003	77.52	518.83	15.95	11.95	316.64	97.11	1.43	18.25
2004	53.98	623.28	10.02	14.34	262.85	98.77	1.71	21.90
2005	243.39	565.25	33.28	15.06	210.64	137.47	1.54	19.70
2006	216.17	582.81	15.11	17.23	366.13	152.91	2.96	37.95
2007	125.78	634.02	8.01	21.57	256.00	172.48	6.61	84.68
2008	240.71	641.10	14.99	23.79	276.44	187.81	9.18	117.52
2009	6.71	1,008.33	24.82	23.12	536.47	264.30	14.59	186.86
2010	7.04	1,030.37	17.63	27.74	416.49	461.17	17.04	218.26
2011	2.40	1,052.91	18.15	35.95	630.16	541.34	19.95	255.48
2012	18.64	1,011.92	9.10	39.80	702.27	508.95	28.39	363.50
2013	20.17	1,269.29	12.68	43.02	824.79	474.60	40.07	513.13
2014	12.29	912.14	14.11	38.13	765.34	482.22	57.80	740.14
2015	7.40	828.58	14.11	32.66	486.45	406.34	68.46	876.63
2016	8.65	1,202.56	11.14	30.46	1,009.75	588.35	64.41	824.82
2017	7.11	1,105.45	9.58	44.76	722.34	708.63	59.53	762.33
2018	6.15	1,247.22	5.59	47.18	1,213.93	757.93	49.89	638.80
2019	4.90	876.67	8.35	60.05	1,853.04	799.30	53.69	687.54
2020	4.80	891.26	10.93	57.08	903.51	692.75	32.06	410.55
Diff % 1990/2020	*72.66*	*6.09*	*-95.35*	*182.16*	*33.50*	*429.18*	*-*	*-*
Diff % 2019/2020	*-2.04*	*1.66*	*30.90*	*-4.95*	*-51.24*	*-13.33*	*-40.29*	*-40.29*

3.1.1 Methodological issues

The emissions from energy sector were calculated using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (the 2006 IPCC GLs) and applying the Tier 1 and Tier 2 methods. The choice of the method was made in accordance with the decision tree of the 2006 IPCC GLs. The Tier 1 method was applied for the emission estimation from combustion of oil products such as diesel oil, motor gasoline, jet fuel, residual fuel oil, lubricants. The Tier 2 method, i.e., the country-specific net calorific values (NCVs) and CO_2 emission factors (EFs) were applied for the emission estimation from coal combustion such as other bituminous coal and lignite. Regarding the CH_4 and N_2O EFs, the default values were used. The activity data from national statistics and International Energy Agency (IEA) was used. In cases where the data is not available in both statistics, data from some relevant organizations were used, e.g., from Ulaanbaatar Railways Joint Stock Company and Mineral Resources and Petroleum Authority (MRPAM).

A summary description of methods used to estimate emissions by categories is provided in the Table 3-4, while a more detailed description is available in chapters 3.2-3.3 of this report.

Table 3-4: Summary of methods used to estimate GHG emissions from the energy sector

Source categories	*CO_2*		*CH_4*		*N_2O*	
	Method	*EF*	*Method*	*EF*	*Method*	*EF*
1.A.1 - Energy industries	T1, T2	D, CS	T1	D	T1	D
1.A.2 - Manufacturing industries and construction	T1, T2	D, CS	T1	D	T1	D
1.A.3 -Transport	T1	D	T1	D	T1	D
1.A.4 - Other sectors	T1, T2	D, CS	T1	D	T1	D
1.A.5 - Non-specified	T1, T2	D, CS	T1	D	T1	D
1.B.1 - Fugitive emissions from fuels (solid fuels)	-	-	T1	D	-	-
1.B.2 - Fugitive emissions from fuels (oil)	T1	D	T1	D	T1	D

Abbreviations: T1=Tier 1 method, T2=Tier 2 method, EF=emission factor, D=default EF, CS=country-specific

Regarding biomass combustion, it is a special case that CO_2 emissions from biomass fuels (e.g., other primary solid biomass) are estimated and reported in the agriculture, forestry and other land use (AFOLU) sector as part of of the AFOLU methodology. In the reporting table, emissions from combustion of biomass are reported as information items but not included in the energy national totals. For biomass, only that part of the biomass that is combusted for energy purposes should be estimated for inclusion as an information item in the energy sector. The emissions of CH_4 and N_2O, however, are estimated and included in the sector and national totals because their effect is in addition to the stock changes estimated in the AFOLU sector (IPCC, 2006 p. 2.33).

3.1.2 Key categories

The key categories of the energy sector (excluding LULUCF) in 2020 by level and trend are presented in the Table 3-5. These key categories were selected as a result of overall key category analysis conducted using the Tier 1 method. The CO_2 emissions from energy industries (solid fuels), road transportation, railways, other transportation, other sectors (solid fuels), non-specified (solid fuels), the fugitive CH_4 emissions from solid fuels and oil were included in both level and trend assessments as key categories. The CO_2 emissions from energy industries (liquid fuels), manufacturing industries and construction, and CH_4 emissions from other sectors (solid fuels) were included in the trend assessment as key categories. Results of KCA including LULUCF, were conducted using fewer categories, such as energy industries-liquid fuels (CO_2), railways (CO_2) and other sectors-solid fuels (CH_4). More detailed information on key categories is provided in Annex II.

Table 3-5: Key categories analysis under the energy sector (excluding LULUCF)

IPCC code	*Source categories*	*GHGs*	*Key categories*
1.A.1	Energy industries – solid fuels	CO_2	Yes (L, T)
1.A.1	Energy industries – liquid fuels	CO_2	Yes (T)
1.A.2	Manufacturing industries and construction – solid fuels	CO_2	Yes (T)
1.A.3.b	Road transportation	CO_2	Yes (L, T)
1.A.3.c	Railways	CO_2	Yes (L, T)
1.A.3.e	Other transportation	CO_2	Yes (L, T)
1.A.4	Other sectors – solid fuels	CO_2	Yes (L, T)
1.A.4	Other sectors – solid fuels	CH_4	Yes (T)
1.A.5	Non-specified – solid fuels	CO_2	Yes (L, T)
1.B.1	Solid fuels	CH_4	Yes (L, T)
1.B.2.a	Oil	CH_4	Yes (L, T)

Abbreviations: L=level assessment of key category analysis (KCA), T=trend assessment of KCA

3.1.3 Uncertainty assessment and time series consistency

Uncertainties related to estimation of CO_2, CH_4 and N_2O emissions from the energy sector, in particular depend on the accuracy of main data source of activity data, like energy balance table. In the energy sector, the IPCC default uncertainty values for activity data and emission factors have been used where applicable. More detailed information on uncertainty assessment is provided in Annex III.

3.1.4 Quality assurance and Quality control (QA/QC)

In the current submission, all applied information and data have been double-checked by national expert. For instance, the activity data (AD) of the energy sector taken from the energy balance tables of the International Energy Agency (IEA) was cross-checked against the data from National Statistics Office of Mongolia (NSO). The sector experts cross-checked the activity data and emission factors and/or other parameters for other sectors. All AD, EFs, assumptions and calculations were documented and archived both in hard copies and electronically.

3.1.5 Source-specific recalculations

A recalculation in this category is done in this submission, due to the application of the higher tier method. Country-specific CO_2 EFs and net calorific values (NCVs) for lignite and other bituminous coal were applied. The comparison of results from the inventory from iBUR and BUR2 are shown in the Table 3-6.

Table 3-6: Recalculated GHG emissions from the energy sector, in the iBUR and second BUR of the Mongolia, 1990-2014, Gg CO_2e

Years	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
iBUR	11,091.14	12,879.99	11,225.37	10,407.61	9,093.72	8,920.66	7,290.90	7,094.52	7,204.28
BUR2	12,086.75	12,218.09	10,589.40	10,062.97	8,751.24	8,752.15	8,466.61	8,306.43	8,339.22
Diff (%)	8.98	-5.14	-5.67	-3.31	-3.77	-1.89	16.13	17.08	15.75
Year	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
iBUR	7,174.94	7,528.89	7,547.49	8,068.76	7,967.05	8,125.47	9,738.30	11,503.25	11,930.76
BUR2	8,385.13	8,792.39	8,786.65	9,398.39	9,119.37	9,370.65	9,833.17	11,039.76	11,715.13
Diff (%)	16.87	17.78	16.42	16.48	14.46	15.32	0.97	-4.03	-1.81

Year	2008	2009	2010	2011	2012	2013	2014
iBUR	11,919.81	12,491.36	13,227.35	14,823.77	16,357.95	17,762.11	17,267.79
BUR2	11,836.39	12,333.01	13,344.88	14,308.90	15,637.24	16,942.32	16,902.95
Diff (%)	-0.7	-1.27	0.89	-3.47	-4.41	-4.62	-2.11

Abbreviations: iBUR=Mongolia's initial Biennial Update Report under the UNFCCC, August 2017; BUR2=Mongolia's Second Biennial Update Report under the UNFCCC, 2023.

Note:The positive percentages mean an increase, while the negative percentages mean a decrease in emissions.

For example, in 1990, GHG emissions from energy sector were 11,091.14 Gg CO_2e in iBUR, while this figure increased by 8.98% to 12,086.75 Gg CO_2e in BUR2. Comparisons were conducted from 1990 to 2014.

3.1.6 Assessment of completeness

The inventory covers GHG emissions for the period of 1990-2020 for following categories: energy industries (1.A.1) including electricity generation, combined heat and power generation and other energy industries; manufacturing industries and construction (1.A.2), transport (1.A.3) including civil aviation, road transportation, railways and other transportation; other sectors (1.A.4) including commercial/institutional, residential and agriculture; non-specified (1.A.5) including stationary combustion; fugitive emissions from fuels (1.B) including surface mining, oil flaring and oil production and upgrading. Table 3-7 shows the overview of the estimation completeness status under source categories within the energy sector.

Table 3-7: Assessment of completeness of GHG emissions from energy sector

IPCC categories	Source categories	Gases		
		CO_2	CH_4	N_2O
1.A.1-Energy industries	1.A.1.a-Main activity electricity and heat production	E	E	E
	1.A.1.a.i-Electricity generation	E	E	E
	1.A.1.a.ii-Combined heat and power generation	E	E	E
	1.A.1.a.iii-Heat plants	NA	NA	NA
	1.A.1.b-Petroleum refining	NO	NO	NO
	1.A.1.c-Manufacture of solid fuels and other energy industries	E	E	E
	1.A.1.c.i-Manufacture of solid fuels	NA	NA	NA
	1.A.1.c.ii-Other energy industries	E	E	E
1.A.2-Manufacturing industries and construction		E	E	E
1.A.3-Transport	1.A.3.a-Civil aviation	E	E	E
	1.A.3.a.i-International aviation (international bunkers)	E	E	E
	1.A.3.a.ii-Domestic aviation	E	E	E
	1.A.3.b-Road transportation	E	E	E
	1.A.3.c-Railways	E	E	E
	1.A.3.d-Water-borne navigation	NA	NA	NA
	1.A.3.e-Other transportation	E	E	E
	1.A.3.e.i-Pipeline transport	NO	NO	NO
	1.A.3.e.ii-Off-road	E	E	E
1.A.4-Other sectors	1.A.4.a-Commercial/institutional	E	E	E
	1.A.4.b-Residential	E	E	E
	1.A.4.c-Agriculture/forestry/fishing/fish farms	E	E	E
	1.A.4.c.i-Stationary	E	E	E
	1.A.4.c.ii-Off-road vehicles and other machinery	E	E	E
	1.A.4.c.iii-Fishing (mobile combustion)	NE	NE	NE
1.A.5-Non-specified	1.A.5.a-Stationary	E	E	E
	1.A.5.b-Mobile	NE	NE	NE
	1.A.5.c-Multilateral operations	NA	NA	NA
-	1.B.1-Solid fuels	-	E	-
	1.B.1.a-Coal mining and handling	-	E	-
	1.B.1.a.i-Underground mines	-	NA	-
	1.B.1.a.ii-Surface mines	-	E	-
	1.B.1.a.ii.1-Mining	-	E	-

	1.B.1.a.ii.2-Post-mining seam gas emissions	-	E	-
	1.B.1.b-Uncontrolled combustion and burning coal dumps	-	NO	-
	1.B.1.c-Solid fuel transformation	-	NA	-
	1.B.2-Oil and natural gas	E	E	E
	1.B.2.a-Oil	E	E	E
	1.B.2.a.i-Venting	NA	NA	NA
	1.B.2.a.ii-Flaring	E	E	E
	1.B.2.a.iii-All other	E	E	NE
	1.B.2.a.iii.2-Production and upgrading	E	E	NE*
	1.B.2.b-Natural gas	NO	NO	NO
	1.B.3-Other emissions from energy production	NE	NE	NE
1.C-Carbon dioxide transport and storage		NO	-	

Abbreviations: E- Estimate, source categories included in the inventory; NA-Not Applicable; NO-Not Occurring
** Not estimated, because the N_2O EF is not available in the guidelines.*

3.1.7 Sector-specific planned improvements

In general, priority is given to improvement according to the 2006 IPCC GLs for key categories. In iBUR, Mongolia applied the Tier 1 method and planned further improvements. As indicated in iBUR, Mongolia has started to develop its national energy balance tables. The national Energy Balance Tables (EBTs) are main tools to estimate the GHG emissions from energy sector as well as to develop domestic energy policies. Although Mongolia had developed national EBTs in the past, however, Mongolia does not have a national system for the continuous development of EBTs. The draft of EBTs for the years 1990-2020 were jointly developed by the Mongolian Energy Economics Institute (MEEI) and NSO with the financial and technical support from the Japan International Cooperation Agency (JICA) from June 2021 to January 2022. However, the EBT drafts were not used in the national GHG inventory for the current submission (BUR2), because drafts are under overview of the national experts from relative professional organizations to be used in subsequent submissions.

As in the improvement plan elaborated, the estimation of fugitive emissions other than oil production should be covered if the activity data is available, e.g., oil venting and flaring, distribution of oil products etc. The fugitive emissions from oil flaring are covered for this submission, but the emissions from the distribution of oil products is not included due to lack of data. For the oil production process, the fugitive emissions from oil production were assumed to be flared due to lack of data.

3.2 Fuel combustion activities (1.A)

3.2.1 Energy industries (1.A.1)

In 2020, Mongolia's electricity production has reached 7,145.7 million kWh, an increase of 2.0% or 142.4 million kWh compared to the previous years' production, 2019. The 90.9% of total electricity was produced by combined heat and power plants (CHPs), 7.9% by solar and wind, 1.2% by hydropower sources, and 0.03% by diesel generators. Total heat energy production has been reached 10,705.1 thousand Gcal, an increase of 3.8% or 394.2 thousand Gcal compared to the previous year. The electricity import is decreased by 0.6% or 10.2 million kWh up to 1,705.6 million kWh in 2020 compared to previous year. Mongolia's power system consists of five interconnected but mostly separate grid network such as the central region integrated power grid (CRIPG), eastern region integrated power grid (ERIPG), western region integrated power grid (WRIPG), Altai-Uliastai integrated power grid (AUIPG) and southern region integrated power grid (SRIPG). The CRIPG is the largest, which covers around 78% of total power generation, and the most complex grid among others.

The share of electricity generated by diesel generators in the total production was 0.06% in 2017, 0.05% in 2018, 0.04% in 2019, and 0.03% in 2020 indicating that the diesel consumption by diesel generators is decreasing. The electricity imports was 19.7%, and 19.3% in 2019 and 2020, respectively, as the increase in domestic electricity production leads to decrease in the imported electricity.

3.2.1.1 Category description

The energy industries of Mongolia covers emissions from electricity generation (1.A.1.a.i), combined heat and power generation (1.A.1.a.ii), and other energy industries (1.A.1.c.ii) source categories. As stated above the share of energy industries in the energy sector was relatively high (53.02%) from the base year and increased over the years up to 72.35% in 2000, and it has been decreased to 57.51% in 2020.

Electricity generation

Under the subcategory electricity generation (1.A.1.a.i) the diesel generators were covered with share of 3.17%, under combined heat and power generation (1.A.1.a.ii) were covered the CHPs with share of 96.71% and under other energy industries (1.A.1.c.ii) were covered the emissions from other transformation of coke oven gas and primary solid biomass with share of 0.12% in 2020 (Figure 3-3). Emissions from heat plants were not estimated due to data lack of data and these will be included in next submission.

Combined heat and power generation

Internationally, combined heat and power generation (CHP) represents a series of proven, reliable, and cost-effective technologies that are already making an important contribution to meeting global heat and electricity demand. Mongolia's CHPs are coal and residual fuel oil fired plants. The CRIPG consists of eight CHPs and three thermal power plants, of which 3 CHPs and one thermal plant are located in the capital city of Ulaanbaatar.

Manufacture of solid fuels and other energy industries

Under this subcategory have been calculated GHG emissions from production process of coking coal to coke oven coke and coke oven gas. The coke oven gas combustion for the generation of electricity and heat for own use is considered in the "other energy industries" subcategory, while the coke oven coke combustion is considered under the category "manufacturing industries and construction".

Figure 3-3 shows the GHG emissions from energy industries are gradually increasing due to growing demand of electricity and heat, and slightly decreased during the Covid-19 pandemic period when manufacturing industries like cement, iron and steel production were closed. Another main reason for the emissions decreases from 2018 is the Government of Mongolia issued a resolution (No.62) to ban the domestic use of raw coal on 28th of February, 2018. The resolution is to ban the use of raw coal by special license holders of heat and power generation operating in the Bayangol, Bayanzurkh, Songinokhairkhan, Sukhbaatar, Khan-Uul, Chingeltei and Nalaikh districts of Ulaanbaatar city, as well as citizens, enterprises, and organizations, except for CHP2, CHP3, CHP4, Amgalan, Selbe and Nalaikh thermal plants. This resolution came into force on 15th of May, 2019. Thus, the emissions in 2019 have not reduced directly compared to 2018, but as of 2020 the emissions have reduced already by 3.58%.

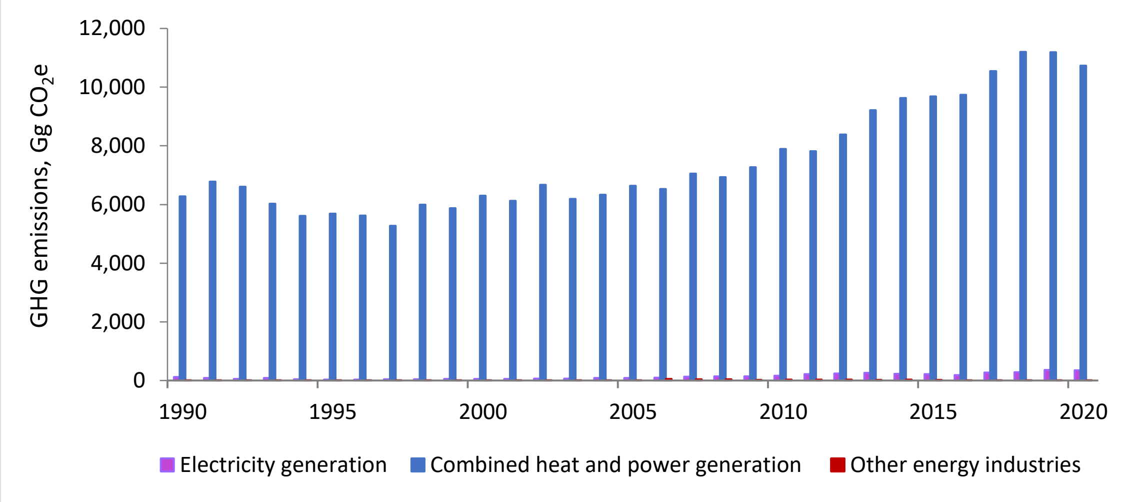

Figure 3-3: Emissions from energy industries by subcategories, Gg CO_2e

More than 90% of total emissions are caused by the subcategory CHP plants in the energy industries category. Table 3-8 shows the emissions from energy industries by subcategories expressed in Gg CO_2e.

Table 3-8: Emissions from energy industries by subcategories, Gg CO_2e

Years	*Electricity generation*	*Combined heat and power generation (CHPs)*	*Other energy industries*	*TOTAL ENERGY INDUSTRIES*
1990	124.64	6,281.03	2.53	6,408.20
1991	90.40	6,778.75	2.53	6,871.68
1992	55.47	6,603.87	2.76	6,662.10
1993	96.56	6,023.02	3.00	6,122.58
1994	44.52	5,609.28	3.00	5,656.80
1995	38.69	5,692.96	3.00	5,734.65
1996	41.09	5,626.25	3.00	5,670.34
1997	43.83	5,275.07	3.23	5,322.13
1998	44.52	5,996.23	3.23	6,043.98
1999	54.44	5,874.18	3.23	5,931.85
2000	55.47	6,300.78	5.07	6,361.32
2001	59.58	6,131.48	5.76	6,196.82
2002	65.40	6,669.44	6.45	6,741.29
2003	73.62	6,193.82	6.45	6,273.89
2004	88.34	6,329.76	6.45	6,424.55
2005	92.79	6,641.23	6.45	6,740.47
2006	106.14	6,527.46	61.71	6,695.31
2007	132.86	7,054.33	43.93	7,231.12
2008	146.56	6,931.33	44.42	7,122.31
2009	142.44	7,269.86	30.12	7,442.42
2010	170.86	7,894.76	36.69	8,102.31
2011	221.54	7,813.51	34.69	8,069.74
2012	245.16	8,381.85	36.86	8,663.87
2013	265.03	9,217.61	31.26	9,513.90
2014	234.89	9,630.66	35.13	9,900.68
2015	224.27	9,684.32	25.53	9,934.12
2016	187.64	9,740.70	13.08	9,941.42
2017	275.74	10,545.18	15.14	10,836.06
2018	290.64	11,198.20	18.91	11,507.75
2019	369.94	11,186.83	18.65	11,575.42
2020	351.62	10,730.08	13.70	11,095.40

3.2.1.2 Methodological issues

3.2.1.2.1 Choice of method

In general, emissions of each greenhouse gas (CO_2, CH_4 and N_2O) from stationary sources are calculated by multiplying fuel consumption by the corresponding emission factors. In the "Sectoral approach", "fuel consumption" is estimated from energy use statistics and is measured in Terajoules (TJ). Fuel consumption data in mass or volume units initially must be converted into the energy content of the fuel. All Tiers described in the 2006 IPCC GLs the activity data is the amount of fuel combusted. Applying a Tier 1 method emission estimate requires the data on the amount of fuel combusted in each source category and a default emission factor from the 2006 IPCC GLs. A Tier 2 method requires data on the amount of fuel combusted in each source category and a country-specific emission factors for the source category and fuel for each gas. Country-specific emission factors can be developed by taking into account country-specific data and conditions, for example carbon contents of the fuels used, carbon oxidation factors and fuel calorific values (the 2006 IPCC GLs). In Mongolia, a net calorific value is used as a conversion factor.

The emissions from energy industries were calculated using the Tier 1 and Tier 2 methods of the 2006 IPCC GLs. The choice of the method was made in accordance with the decision tree of the 2006 IPCC GLs. For Tier 1 method were applied diesel oil consumption of diesel generators from National Statistics office (NSO) and International Energy Agency (IEA), and the default Net Calorific Values (NCVs) and CO_2, CH_4, and N_2O emission factors (EFs) from the 2006 IPCC GLs. For Tier 2 method were applied fuel consumption data from NSO and IEA and the country-specific NCVs, CO_2 EFs and carbon contents for coking coal, other bituminous coal and lignite (ERC, 2021). EFs for CH_4 and N_2O were obtained from the IPCC default values.

3.2.1.2.2 Activity data

The main source of activity data for the energy sector is the energy balance tables in many countries, and likewise Mongolia is developing its own energy balance tables for time series (1990-2020), but currently these tables are not used in the GHG inventory. Mongolia will make every effort to use its energy balance tables for the subsequent reports for submissions.

For the emissions estimation from diesel electricity generators, the consumption of diesel oil was taken from the oil products balance of IEA and cross-checked with national statistics data from NSO and the diesel oil consumption analysis data from mineral Resources and Petroleum Authority of Mongolia (MRPAM). The coal and residual oil consumption data of CHPs was taken from coal and oil balances of IEA statistics and cross-checked with the NSO data. There were some cases where the total consumption of coal did not match, and they were adjusted based on the numbers from national statistics. The discrepancy between both data sources was not too high, so the IEA data was applied to the GHG inventory. To prepare the activity data for the emission estimations the IEA numbers in "TJ" (terajoules) units were converted into "kt" (kilotonnes) units using NCVs from the IEA.

Table 3-9: The conversion factors (NCVs) used in the preparation of activity data

Coking coal	*Other bituminous coal*	*Lignite*	*Coke oven coke*
NCV (TJ/Gg)			
28.200*	28.596**	14.403**	28.200*

** The IPCC default values, ** IEA values.*

According to the 2006 IPCC GLs, the default values of uncertainties for activity data have been applied (Table 3-11).

3.2.1.2.3 Emission factors and other parameters

The basic equations used to estimate GHG emissions under the energy sector are described below:

$$CO_2\ Emissions = \Sigma_j\ (Fuel\ Consumption_j \bullet Conversion\ Factor\ [TJ/unit] \bullet Carbon\ Emission\ Factor_j\ [t\ C/TJ] - Carbon\ Stored \bullet Oxidation\ Fraction_j \bullet 44/12)\ and$$

$$Non\text{-}CO_2\ Emissions = \Sigma_j\ (Fuel\ Consumption_j \bullet Emission\ Factor_j)$$

Where: j = type of fuel

The IPCC default net NCVs and CO_2, CH_4 and N_2O EFs for diesel oil were applied in this category (see Table 3-10). The uncertainty of EFs for diesel oil are shown in the Table 3-11. The Revised 1996 IPCC GLs (Table A1-1, Vol. 1, p. A1.4) suggest an overall uncertainty value of ±7% for the CO_2 EFs of energy.

Table 3-10: EFs and other parameters for stationary combustion in the energy industries (IPCC defaults and *country-specific values)

Fuel	*NCVs (TJ/Gg)*	*Carbon contents (kg/GJ)*	*CO_2 EFs (kg CO_2/TJ)*	*CH_4 EFs (kg CH_4/TJ)*	*N_2O EFs (kg N_2O /TJ)*
Gas/Diesel oil	43.0	20.2	74,100	3.0	0.6
Residual fuel oil	40.4	21.1	77,400	3.0	0.6
Lignite	14.4*	27.0*	97,100*	1.0	1.5
Other bituminous coal	18.1*	24.5*	88,300*	1.0	1.5
Coke oven gas	38.7	12.1	44,400	1.0	0.1
Other primary solid biomass	11.6	27.3	100,000	30.0	4.0

** Source for country-specific NCVs and CO_2 EFs: ERC report report "Develop a national methodology for determining GHG emissions in the energy sector", 2021 (the report is in Mongolian), Table 3-7, p.37.*
Sources for the IPCC defaults: NCVs and CCs - 2006 IPCC GLs, Vol. 2, Ch. 1, Table 1.2, p. 1.18, Table 1.3 and 1.4, pp. 1.21, 1.23. Default CO_2, CH_4 and N_2O EFs – 2006 IPCC GLs, Vol. 2, Ch. 2, Table 2.2, p. 2.16.

Table 3-11 provides the default uncertainty values and the sources for activity data and emission factors. The national uncertainty values for activity data and emission factors were not developed.

Table 3-11: The default uncertainty values for the activity data and emission factors

Sector	*Uncertainty values*		*Sources*
	Surveys	*Extrapolations*	
	Uncertainty for activity data		
Main activity electricity and heat production	1-2%	5-10%	2006 IPCC GLs, Vol. 2, Ch. 2, p. 2.41, Table 2.15 (less developed statistical systems)
Commercial, institutional, residential combustion	10-15%	15-25%	
Industrial combustion (energy intensive industries)	2-3%	5-10%	
Industrial combustion (others)	10-15%	15-20%	
Biomass in small sources	30-60%	60-100%	
Gases	*Uncertainty for emission factors*		
CO_2	±7%		2006 IPCC GLs, Vol. 2, Ch. 2, p. 2.38, Section 2.4.1, Paragraph 2.
CH_4	50-150%		2006 IPCC GLs, Vol. 2, Ch. 2, p. 2.38, Section 2.4.1, Table 2.12.
N_2O	Order of magnitude*		

** i.e. having an uncertainty range from one-tenth of the mean value to ten times the mean value.*

3.2.1.3 Category-specific recalculations

Since the energy industries (solid fuels) is a key category (iBUR, 2017) higher Tier method is recommended to apply. The Tier 1 method was applied to the energy industries, because the diesel oil is imported fuel in Mongolia. The Tier 2 method was applied to the fuel combustion category for coal types, and the recalculation is performed for the entire time series for the period 1990-2020.

3.2.1.4 Category-specific planned improvements

As described in the Chapter 3.1.7, the national energy balance tables are the main source of activity data that are not yet finalized and ready for use in the national GHG inventory. Therefore, the energy balance tables of the IEA were used. The national energy balance tables will be revised by the Mongolian Energy Economics Institute (MEEI) and NSO in consultation with relevant stakeholders and will be used in subsequent submissions. Emissions from some subcategories, such as heat plants and distribution of oil products, were not estimated due to data lack, thus the data collection of those subcategories will be improved.

3.2.2 Manufacturing industries and construction (1.A.2)

3.2.2.1 Category description

According to the 2006 IPCC GLs, the emissions from fuel combustion in industry sectors are covered in this category. The manufacturing industries are as follows: iron and steel, non-ferrous metals, chemicals, pulp, paper and print, food processing, beverages and tobacco, non-metallic minerals, transport equipment, machinery, mining (excluding fuels) and quarrying, wood and wood products, textile and leather, non-specified industry. As the fuel combustion data is not available by industry sectors, the emissions from this category were estimated in aggregated manner. After the democratic revolution (e.g. 1990), the industry and construction sectors experienced a sharp decline for more than ten years. In 2006, there was a boom in the construction sector, and it slowly started to revive after. During the revival, new techniques and technologies continued to be entered into these industries (see Figure 3-2). The general trend of emissions in this category is tending to decrease over time series due to the introduction of new techniques and technologies in construction and industry sectors, leading to a reduced combustion of raw coal.

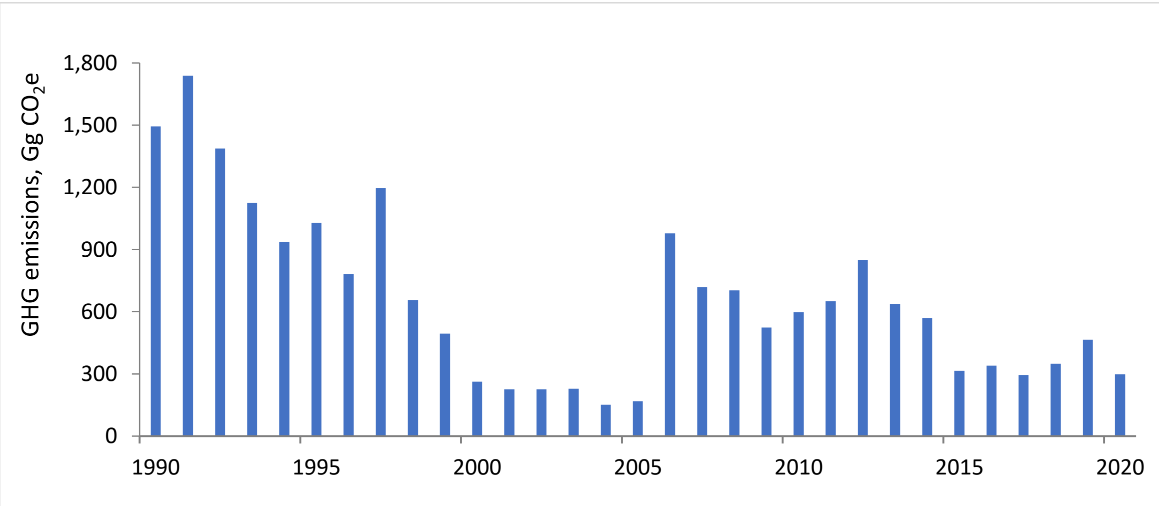

Figure 3-4: Emission trend of manufacturing industries and construction category, Gg CO_2e

GHG emissions in the manufacturing industries and construction category are calculated in aggregated manner, because the activity data/coal consumption data were not available by manufacturing industries as listed above.

Table 3-12: Emissions from manufacturing industries and construction category, Gg CO_2e

Category											
Manufacturing industries and construction	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
	1,494.38	1,738.05	1,386.98	1,124.45	936.25	1,029.55	781.30	1,196.54	656.02	494.09	262.87
	2001	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
	224.53	225.72	228.51	150.26	168.24	977.33	717.84	702.83	523.06	597.94	649.72
	2012	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*		
	850.07	637.44	570.14	315.26	339.11	294.72	349.25	464.66	297.25		

3.2.2.2 Methodological issues

3.2.2.2.1 Choice of method

The Tier 2 method was applied for this category, for example the country-specific NCVs and CO_2 EFs for other bituminous coal and lignite. The IPCC default values were used to estimate the CH_4 and N_2O emissions for Tier 1 method.

3.2.2.2.2 Activity data

The aggregated consumption data of other bituminous coal, lignite, and coke oven coke were taken from the coal balances of IEA and cross-checked with national statistics data from NSO. According to the 2006 IPCC GLs the emissions from the transformation of cokes were reported as follows: the emissions from combustion of coke oven gas (industry own use) were reported under 1.A.1.c-Other energy industries and the emissions from combustion of coke oven coke were reported under this category. Same as in the energy industries category, the NCVs from the IEA were used to convert the activity data in TJ units to kt units (Table 3-13).

Table 3-13: The conversion factors (NCVs) used in the preparation of activity data

Coking coal	*Other bituminous coal*	*Lignite*	*Coke oven coke*
NCV (TJ/Gg)			
28.200*	28.596**	14.403**	28.200*

** The IPCC default values, ** IEA values.*

3.2.2.2.3 Emission factors and other parameters

The country-specific net calorific values (NCVs), CO_2 emission factors (EFs) and carbon contents for other bituminous coal and lignite were applied (ERC, 2021), but for CH_4 and N_2O EFs used the IPCC default values. The IPCC default emission factors (EFs) of CH_4 and N_2O for coal each type were applied. The default EFs for stationary combustion in the manufacturing industries and construction category were taken from the 2006 IPCC GLs, Vol. 2, Ch. 2, Table 2.3, p. 2.18, and the default NVCs were taken from the 2006 IPCC GLs, Vol. 2, Ch. 1, Table 1.2, p. 1.18.

Table 3-14: EFs and other parameters for stationary combustion in the manufacturing industries and construction category

Fuel	*NCVs, (TJ/Gg)*	*Carbon content, (kg/GJ)*	*CO_2 EFs, (kg CO_2/TJ)*	*CH_4 EFs, (kg CH_4/TJ)*	*N_2O EFs, (kg N_2O/TJ)*
Other bituminous coal	18.1*	24.5*	86,700*	1.0	1.5
Lignite	14.4*	27.0*	95,400*	1.0	1.5
Coke oven coke	28.2	29.2	107,000	1.0	1.5

** Country-specific values from ERC report "Develop a national methodology for determining GHG emissions in the energy sector", 2021 (the report is in Mongolian), Table 3-7, p.37. All others are IPCC defaults.*

3.2.2.3 Category-specific recalculations

Since the manufacturing industries and construction (solid fuels) is a key category (iBUR, 2017) the Tier 2 method is recommended to apply. Thus the Tier 2 method (country-specific NCVs, CO_2 EFs) has been applied to this category for other bituminous coal and lignite, and the recalculation is performed for the entire time series, 1990-2020.

3.2.2.4 Category-specific planned improvements

As described in the Chapter 3.1.7, the main source of activity data is the national energy balance tables, which are not yet finalized and to be used for the national GHG inventory. Therefore, the energy balance tables of the IEA were used. The national energy balance tables will be finalized by MEEI and NSO and it will be used in subsequent submissions.

3.2.3 Transport (1.A.3)

3.2.3.1 Category description

Within the transport category covered GHG emissions from civil aviation (1.A.3.a), road transportation (1.A.3.b), railways (1.A.3.c) and other transportation (1.A.3.e). Same as above subcategories the main GHGs carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) were estimated under the fuel combustion. International bunkers, i.e., emissions from international aviation were estimated and excluded from national totals and reported separately as memo item. The emissions from water-borne navigation were not estimated due to data unavailability.

Civil aviation

This source category includes GHG emissions from all civil and commercial use of airplanes, including civil and general aviation. Here, emissions inventory is distinguished between domestic and international aviation. The emissions from international aviation are not included in the national total and reported separately as memo item.

Road transportation

This source category includes all types of light-duty vehicles such as automobiles and light trucks, and heavy-duty vehicles such as tractor trailers and buses, and on-road motorcycles (including mopeds, scooters, and three-wheelers). Mongolia does not have fuel consumption data by these types of vehicles and therefore the emissions from this source category were estimated in aggregate. The motor gasoline, gas and diesel oil data were derived from foreign trade such as imports and exports in national statistics.

Railways

According to the 2006 IPCC GLs emissions in the railways source category includes GHG emissions from three types of railway locomotives: diesel, electric and steam. In Mongolia exist only diesel locomotives which use diesel engines in combination with an alternator or generator to produce the electricity required to power their traction motors. Mongolia has a harsh winter, so the passenger wagons are heated by coal burning. Line haul locomotives are one of three diesel locomotives and used for long distance rail traction both for freight and passenger.

Other transportation

This source category includes fuel combustion emissions from all remaining transport activities including pipeline transportation, ground activities in airports and harbors, and off-road activities not otherwise reported under 1.A.4.c Agriculture or 1.A.2 Manufacturing industries and construction. In Mongolia's case the emissions from off-road transportation in the mining industries were estimated under this subcategory.

Figure 3-5 shows GHG emission trend in the transport category illustrated by subcategories.

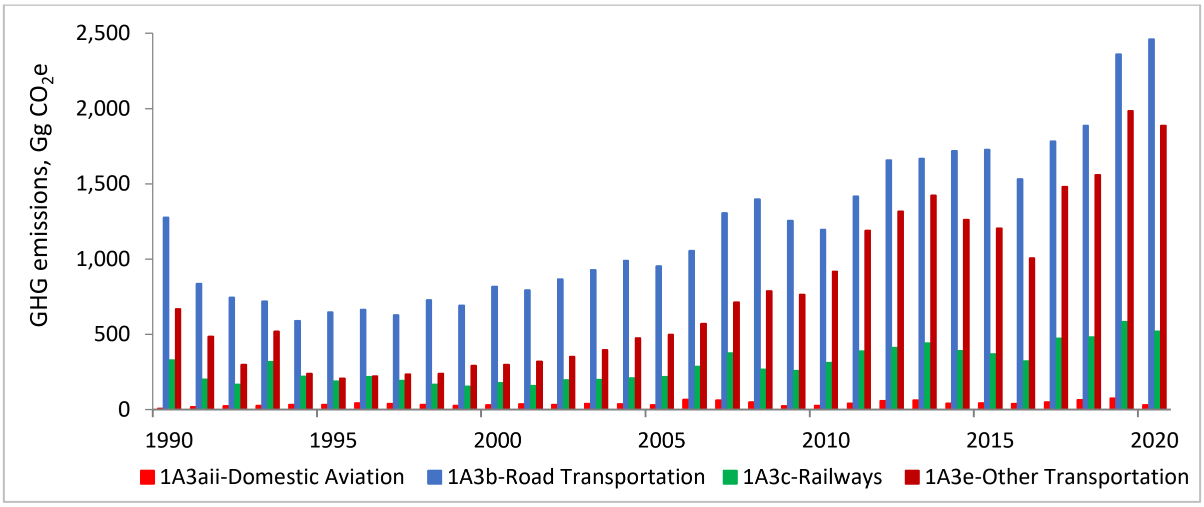

Figure 3-5: Emission trend in the transport sector by subcategories, Gg CO_2e

GHG emissions in this category are gradually increasing in general. GHG emissions from civil aviation are divided into domestic and international aviation, and GHG emissions from domestic aviation are included in the national totals, but the international aviation/bunkers are not included in the national totals and are reported separately as memo items. GHG emissions in 2020 showed a slight decrease compared to the previous year, most likely the quarantine of the Covid-19 pandemic. Table 3-15 shows the GHG emissions from transport sector separated by its subcategory for entire time series.

Table 3-15: GHG emissions from transport by subcategories, Gg CO_2e

Years	*Domestic aviation*	*Road transportation*	*Railways*	*Other transportation*	*TOTAL TRANSPORT*
1990	6.02	1,275.58	327.40	668.85	2,277.86
1991	16.38	836.37	200.64	485.09	1,538.49
1992	23.86	743.99	166.83	297.69	1,232.37
1993	26.72	718.26	316.73	518.18	1,579.90
1994	31.81	589.41	220.21	238.88	1,080.31
1995	32.45	647.67	186.71	207.63	1,074.46
1996	43.74	664.50	216.25	220.49	1,144.98
1997	39.28	627.40	190.94	235.19	1,092.82
1998	33.08	728.67	166.32	238.88	1,166.95
1999	25.29	690.57	154.31	292.16	1,162.32
2000	29.26	816.65	176.42	297.69	1,320.03
2001	36.26	794.37	157.19	319.72	1,307.55
2002	32.60	866.33	196.86	350.97	1,446.77
2003	38.01	927.78	198.43	395.08	1,559.31
2004	36.26	989.77	208.87	474.07	1,708.98
2005	30.06	953.05	217.06	497.95	1,698.12
2006	65.85	1,054.82	285.55	569.62	1,975.84
2007	62.35	1,306.74	374.98	712.95	2,457.02
2008	50.26	1,397.10	265.88	786.46	2,499.71
2009	23.38	1,255.82	258.72	764.39	2,302.32
2010	25.77	1,196.25	309.95	916.90	2,448.87
2011	39.92	1,416.29	388.01	1,188.87	3,033.09
2012	57.58	1,656.17	411.36	1,315.62	3,440.73
2013	61.71	1,667.69	441.61	1,422.22	3,593.23
2014	41.67	1,717.83	389.96	1,260.50	3,409.95
2015	43.42	1,727.66	368.59	1,203.57	3,343.24
2016	39.44	1,531.75	321.41	1,006.96	2,899.56
2017	48.76	1,782.17	472.09	1,479.72	3,782.74
2018	64.10	1,885.73	480.81	1,559.68	3,990.31
2019	74.12	2,361.40	582.57	1,985.21	5,003.30

2020	30.54	2,460.63	518.81	1,886.90	4,896.88

3.2.3.2 Methodological issues

3.2.3.2.1 Choice of method

GHG emissions have been estimated from fuel consumption by vehicles according to the 2006 IPCC GLs. The Tier 1 method was applied to estimate CO_2, CH_4 and N_2O emissions from liquid fuel combustion in civil aviation, road transportation, other transportation and railways. The Tier 2 method, i.e., the country-specific NCVs and CO_2 EFs, was applied to estimate CO_2, CH_4 and N_2O emissions from coal combustion in the railways. Even though the road transportation, railways and other transportation subcategories selected as key categories the Tier 1 method is used because Mongolia imports the most of its oil products from Russia and a small percentage from China, i.e. Mongolia is fully dependent on the import of oil products. The default conversion and emission factors have been used for the emissions estimation.

The general (Tier 1) equation for emissions from transport sector is:

$$Emissions = \Sigma_j\ (Fuel\ Consumption_j\ [kg] \bullet Conversion\ Factor_j\ [TJ/unit] \bullet Emission\ Factor_j\ [kg/TJ])$$

Where: j = fuel type […] = unit of parameter

3.2.3.2.2 Activity data

The consumption of coal, motor gasoline and diesel oil were used as activity data for the emission estimates in the transport category. The coal consumption data for railways were taken from the IEA coal balance tables and cross-checked with national statistics. According to expert judgement, it is assumed that annually imported liquid fuels such as gas/diesel oil, motor gasoline and jet kerosene are consumed within one inventory year in the transport sector. Therefore, the liquid fuel import data were collected from the national statistics. The diesel oil consumption data was disaggregated based on the diesel oil study conducted by the Mineral resources and petroleum authority of Mongolia (MRPAM). MRPAM has collected the wholesale and retail sales data of each year from companies of different subsectors such as mining, oil production, railways, agriculture, road transportation etc. and conducted data analysis. Based on this study the average percentage of diesel oil consumption by subsectors have been calculated and using these percentages the consumption data by subsectors were derived for entire time series of 1990-2020 (Table 3-16).

Table 3-16: Study on diesel oil consumption by sub-sectors, MRPAM

Sub-sectors	*Sub-sectors*	*Yearly average consumption, t/day*	*Percentage, %*	*Aggregated by sub-sectors, %*
Mining	Industry (off-road)	265,000	47.07	52.84
Crude oil production		32,518	5.78	
Railways	Railways	75,600	13.43	13.43
Agriculture (farming)	Agriculture	9,000	1.60	1.60
Intercity transport	Road transportation	12,240	2.17	21.13
City public transport		25,128	4.46	
Local road maintenance		15,000	2.66	
City road maintenance		3,717	0.66	
City express services		1,763	0.31	
Other		61,126	10.86	
Electricity plants	Electricity generation	61,933	11.0	11.0
TOTAL		563,024	100.0	100.0

Source: MRPAM, 2017

3.2.3.2.3 Emission factors and other parameters

Since the Tier 1 method applied for the civil aviation, road transportation, other transportation and railways sub-categories the default conversion (NCVs) and emission factors were used from the 2006 IPCC GLs. For the Tier 2 method the country-specific conversion and CO_2 emission factors were used for coal types such as other bituminous coal and lignite. In the railways the coal is burned for the heating of passenger wagons. The CH_4 and N_2O EFs for all fuels were used as default values from the 2006 IPCC GLs. In the Table 3-17 below there are listed the EFs and NCVs used in GHG inventory estimation.

Table 3-17: EFs and other parameters for transport category

Subcategories	*Fuels*	*NCVs, (TJ/Gg)*	*Carbon content, (kg/GJ)*	*CO_2 EFs, (kg CO_2/TJ)*	*CH_4 EFs, (kg CH_4/TJ)*	*N_2O EFs, (kg N_2O/TJ)*
Civil aviation	*Jet kerosene*	44.1	19.5	71,500	0.5	2.0
Road transportation	*Motor gasoline (vehicles with oxidation catalyst)*	44.3	18.9	69,300	25.0*	8.0*
	Gas/diesel oil	43.0	20.2	74,100	3.9*	3.9*
Railways	*Gas/diesel oil*	43.0	20.2	74,100	4.15***	28.6***
	Other bituminous coal	18.1**	24.5**	86,700**	2.0***	1.5***
	Lignite	14.4**	27.0**	95,400**	2.0***	1.5***
Other transportation	*Gas/diesel oil*	43.0	20.2	74,100	4.15****	28.6****

**Default values from the 2006 IPCC GLs, Vol. 2, Ch. 3, Table 3.2.2, p. 3.21.*
*** Country-specific values from ERC report "Develop a national methodology for determining GHG emissions in the energy sector", 2021 (the report is in Mongolian).*
****Default values from the 2006 IPCC GLs, Vol. 2, Ch. 3, Table 3.4.1, p. 3.43.*
*****Default values from the 2006 IPCC GLs, Vol. 2, Ch. 3, Table 3.3.1, p. 3.36.*

3.2.3.3 Category-specific recalculations

Since the Tier 2 method was applied for this source category, all emissions have been recalculated for entire time series of 1990-2020.

3.2.3.4 Category-specific planned improvements

The transport category is a key category, so improvement should be planned according to the 2006 IPCC GLs. The liquid fuel consumption data by vehicle types should be improved for more accurate emissions estimation in the future.

3.2.4 Other sectors (1.A.4)

Category description

The emissions from fuel combustion in commercial and institutional buildings, in households, in agricultural, forestry industries were covered under this source category.

Commercial and institutional buildings

This source category includes emissions from stationary fuel combustion in all commercial and institutional buildings such as restaurants, office buildings, schools, kindergartens, hotels, etc. The coal could be directly combusted in individual buildings or in boilers.

Residential buildings

This source category includes emissions from stationary fuel combustion in households. In Mongolia there are number of households (private houses and traditional houses called gers) not connected to the central heating system and, therefore, directly burning coal for their needs.

Agriculture / forestry / fishing industries

According to the 2006 IPCC GLs emissions from fuel combustion in agriculture, forestry, fishing industries should be covered in this source category. In Mongolia's case, it covers the stationary and mobile fuel combustion in agricultural industry. Stationary fuel combustion means fuels combusted in pumps, grain drying, horticultural greenhouses and other agricultural industries. Mobile fuel combustion means fuels combusted in off-road vehicles and other machinery on farmlands. The emissions from fuel combustion in forestry and fishing sectors were not included due to data unavailability.

Figure 3-6 shows the emission trend in this category by subcategories such as commercial and institutional, residential buildings, and agricultural industry.

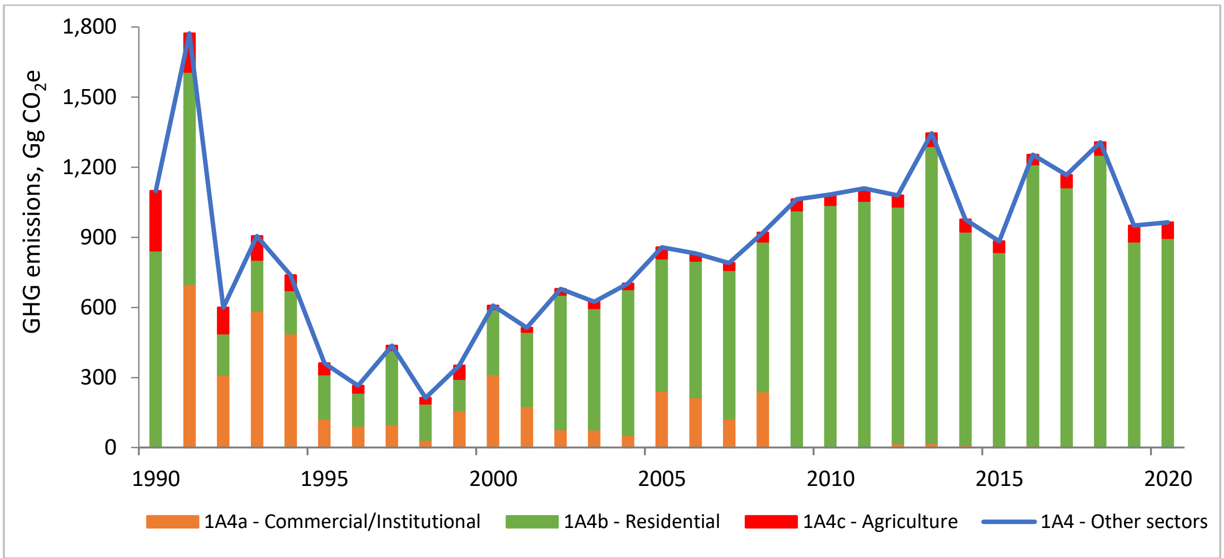

Figure 3-6: GHG emission trend in the other sectors by subcategories, Gg CO_2e

The trend in emissions decreased after the democratic revolution in mid 1990s and then gradually increased until 2018. The main reason is the Government of Mongolia issued a resolution (No.62) to ban the domestic use of raw coal on 28th of February, 2018. The resolution is to ban the use of raw coal by special license holders of heat and power generation operating in the Bayangol, Bayanzurkh, Songinokhairkhan, Sukhbaatar, Khan-Uul, Chingeltei and Nalaikh districts of Ulaanbaatar city, as well as citizens, enterprises, and organizations, except for CHP2, CHP3, CHP4, Amgalan, Selbe and Nalaikh thermal plants. This resolution came into force on 15th of May 2019. In the restricted areas citizens, enterprises and organizations should use the improved coal briquettes instead of raw coal. Table 3-18 shows the GHG emissions from the other sectors separated by its subcategory for entire time series.

Table 3-18: GHG emissions from the other sectors category, Gg CO_2e

Years	*Commercial and institutional*	*Residential*	*Agriculture*	*TOTAL OTHER SECTORS*
1990	2.78	840.13	255.52	1,098.43
1991	700.05	907.75	164.67	1,772.47
1992	312.66	175.17	111.92	599.75
1993	585.17	217.77	102.34	905.28
1994	489.06	183.96	64.48	737.50
1995	124.49	188.35	48.83	361.66
1996	94.04	141.26	30.11	265.41
1997	101.03	316.36	18.81	436.20

1998	33.86	154.54	24.74	213.14
1999	159.07	135.03	57.31	351.40
2000	314.00	278.33	15.49	607.83
2001	178.47	317.11	18.00	513.58
2002	78.86	574.76	25.03	678.65
2003	77.52	518.83	27.90	624.25
2004	53.98	623.28	24.37	701.62
2005	243.39	565.25	48.34	856.99
2006	216.17	582.81	32.34	831.32
2007	125.78	634.02	29.58	789.38
2008	240.71	641.10	38.78	920.59
2009	6.71	1,008.33	47.94	1,062.98
2010	7.04	1,030.37	45.37	1,082.79
2011	2.40	1,052.91	54.11	1,109.42
2012	18.64	1,011.92	48.90	1,079.47
2013	20.17	1,269.29	55.70	1,345.16
2014	12.29	912.14	52.24	976.67
2015	7.40	828.58	46.76	882.73
2016	0.00	0.00	41.60	41.60
2017	7.11	1,105.45	54.34	1,166.90
2018	6.15	1,247.22	52.77	1,306.14
2019	4.90	876.67	68.40	949.97
2020	4.80	891.26	68.01	964.08

3.2.4.1 Methodological issues

3.2.4.1.1 Choice of method

The Tier 1 method was applied to mobile fuel combustion in agricultural industry under the energy fuel combustion category. Because the default net calorific values (NCVs) and emission factors for CO_2, CH_4 and N_2O gases used for liquid fuels such as motor gasoline and diesel oil. The Tier 2 method was applied to stationary fuel combustion in commercial and institutional, residential buildings and agricultural industry. The country-specific NCVs and CO_2 EFs were used for lignite and other bituminous coal, but for CH_4 and N_2O EFs were used the IPCC default values, since the country-specific values were not developed.

3.2.4.1.2 Activity data

The consumption of other bituminous coal, lignite, diesel oil and other primary solid biomass were used as activity data for this subcategory. The coal consumption data for the commercial and institutional, residential and agriculture subcategories were taken from the IEA coal balance tables and cross-checked with national statistics. The diesel oil consumption data for agriculture mobile combustion was taken from the study conducted by MRPAM (see Table 3-16 above). The diesel oil import data from national statistics were multiplied by the average percentage of diesel oil consumption in agricultural industry, and time series data was derived from 1990 to 2020.

The Mongolian Government made a decision to ban the use of raw coal by special license holders of heat and power generation operating in the Bayangol, Bayanzurkh, Songinokhairkhan, Sukhbaatar, Khan-Uul, Chingeltei and Nalaikh districts of Ulaanbaatar city, as well as citizens, enterprises, and organizations, except for CHP2, CHP3, CHP4, Amgalan, Selbe and Nalaikh thermal plants (Government resolution No.62, 2019). Since 2019, following this decision, the improved coal briquettes have been used in the commercial and institutional, as well as the residential subcategories for fuel combustion, but due to insufficient information on this fuel, the GHG emissions have not been calculated.

3.2.4.1.3 Emission factors and other parameters

The IPCC default NCVs and EFs (Tier 1) for diesel oil and other primary solid biomass were taken from the 2006 IPCC GLs. The country-specific NCVs and CO_2 EFs (Tier 2) were used for other bituminous coal and lignite, while for CH_4 and N_2O EFs used the default values. The default CH_4 and N_2O EFs are different by subcategories and should be chosen from different tables from the 2006 IPCC GLs (see Table 3-19).

Table 3-19: EFs and other parameters for other sectors category

Subcategories	*Fuels*	*NCVs, (TJ/Gg)*	*Carbon content, (kg/GJ)*	*CO_2 EFs, (kg CO_2/TJ)*	*CH_4 EFs, (kg CH_4/TJ)*	*N_2O EFs, (kg N_2O/TJ)*
Commercial and institutional	*Lignite*	14.4*	27.0*	95,400*	10.0**	1.5**
	Other bituminous coal	18.1*	24.5*	86,700*	10.0**	1.5**
Residential and Agriculture	*Lignite*	14.4*	27.0*	95,400*	300.0***	1.5***
	Other bituminous coal	18.1*	24.5*	86,700*	300.0***	1.5***
	Other primary solid biomass	11.6****	27.3****	100,000***	300.0***	1.5***
	Gas/diesel oil	43.0****	20.2****	74,100***	10.0***	0.6***

**Country-specific values from ERC report "Develop a national methodology for determining GHG emissions in the energy sector", 2021 (the report is in Mongolian).*
***Default values from the 2006 IPCC GLs, Vol.2, Ch. 2, Table 2.4, p. 2.20.*
****Default values from the 2006 IPCC GLs, Vol. 2, Ch. 2, Table 2.5, p. 2.24.*
*****Default values from the 2006 IPCC GLs, Vol. 2, Ch. 1, Table 1.2, 1.3, pp. 1.18, 1.21.*

3.2.4.2 Category-specific recalculations

Since the Tier 2 method was applied for this source category, all emissions have been recalculated for entire time series of 1990-2020.

3.2.4.3 Category-specific planned improvements

The other sectors category is a key category in terms of solid fuels (see Table 3-5 above), so improvement should be planned according to the 2006 IPCC GLs. The liquid fuel consumption data by sub-sectors should be improved for more accurate emissions estimation in the future. As above mentioned, data on coal consumption by subcategories should be obtained from national energy balance tables, so it is necessary to develop and improve them. Regarding the consumption data of improved coal briquettes, the fuel is newly developed, so there is insufficient information on consumption, carbon content and emission factors. Hence, it is necessary to carry out laboratory analysis to determine the carbon content of the improved coal briquettes, and thus to determine the CO_2 EFs and other relevant parameters for more accurate GHG emissions estimations.

3.2.5 Non-specified (1.A.5)

3.2.5.1 Category description

According to the 2006 IPCC GLs, this source category should cover all remaining emissions from fuel combustion that are not specified elsewhere. It includes emissions from fuel delivered to the military in the country and delivered to the military of other countries that are not engaged in multilateral operations. Since no information was available on military activities in Mongolia, GHG emissions from fuel combustion for military purposes have not been calculated. Under the stationary fuel combustion subcategory should be covered GHG emissions from fuel combustion in stationary sources that are not specified elsewhere, while under the mobile fuel combustion subcategory emissions from vehicles and other machinery, marine and aviation (not included in 1.A.4.c.ii or elsewhere). In case of Mongolia, the consumption data of solid fuels such as lignite, other bituminous coal and other primary solid biomass were obtained from the coal balance tables of the IEA statistics and cross-checked with national statistics. Figure 3-7 shows the emission trend of this source category.

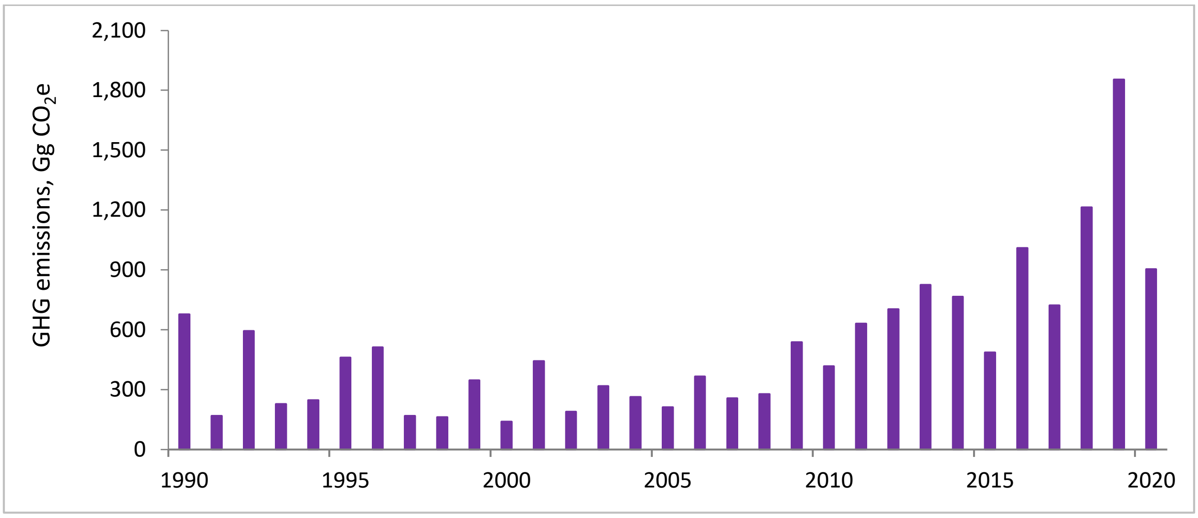

Figure 3-7: GHG emission trend in non-specified source category, Gg CO_2e

Since this source category covers all remaining emissions from stationary fuel combustion that are not specified elsewhere, the emission trend is showing no specific distribution pattern.

Table 3-20: GHG emissions from non-specified source category, Gg CO_2e

Category	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Non-specified	676.77	168.68	593.94	228.02	246.04	460.02	511.11	168.68	161.78	346.80	138.42
	2001	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
	442.27	189.61	316.64	262.85	210.64	366.13	256.00	276.44	536.47	416.49	630.16
	2012	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*		
	702.27	824.79	765.34	486.45	1,009.75	722.34	1,213.93	1,853.04	903.51		

3.2.5.2 Methodological issues

3.2.5.2.1 Choice of method

The Tier 1 method was applied for GHG emissions from combustion of other primary solid biomass. Default values from the 2006 IPCC GLs were used for all EFs and other parameters. The Tier 2 method was applied to GHG emissions from combustion of other bituminous coal and lignite using the country-specific NCVs and CO_2 EFs were available. However, the default CH_4 and N_2O EFs were used for respective emissions calculations.

3.2.5.2.2 Activity data

The consumption of other bituminous coal, lignite and other primary solid biomass were used as activity data for this subcategory. The consumption data of these solid fuels were obtained from the IEA coal balance tables and cross-checked with national statistics.

3.2.5.2.3 Emission factors and other parameters

The IPCC default NCVs and EFs (Tier 1) for diesel oil and other primary solid biomass were taken from the 2006 IPCC GLs. The country-specific NCVs and CO_2 EFs (Tier 2) were used for other bituminous coal and lignite, while for CH_4 and N_2O EFs used the default values. The default CH_4 and N_2O EFs are different for each subcategory and should be chosen from different tables of the 2006 IPCC GLs (Table 3-21).

Table 3-21: EFs and other parameters for non-specified source category

Category	*Fuels*	*NCVs, (TJ/Gg)*	*Carbon content, (kg/GJ)*	*CO_2 EFs, (kg CO_2/TJ)*	*CH_4 EFs, (kg CH_4/TJ)*	*N_2O EFs, (kg N_2O/TJ)*
Non-specified	*Lignite*	14.4*	27.0*	95,400*	1.0**	1.5**
	Other bituminous coal	18.1*	24.5*	86,700*	1.0**	1.5**
	Other primary solid biomass	11.6***	27.3***	100,000**	1.0**	1.5**

**Country-specific values from ERC report "Develop a national methodology for determining GHG emissions in the energy sector", 2021 (the report is in Mongolian).*
***Default values from the 2006 IPCC GLs, Vol.2, Ch. 2, Table 2.2, p. 2.16.*
****Default values from the 2006 IPCC GLs, Vol. 2, Ch. 1, Table 1.2, 1.3, pp. 1.18, 1.21.*

3.2.5.3 Category-specific recalculations

The Tier 2 method was applied for this source category, thus, all emissions have been recalculated for entire time series of 1990-2020.

3.2.5.4 Category-specific planned improvements

The non-specified source category is a key category in terms of solid fuels (see Table 3-5), so improvement should be planned according to the 2006 IPCC GLs. As above mentioned, data on coal consumption by subcategories should be obtained from national energy balance tables, so it is necessary to develop and improve them.

3.2.6 Comparison of the sectoral approach with the reference approach

In the context of international climate protection, the reporting on fuel combustion related CO_2 emissions due to the dominant share of the total emissions are of the utmost importance.

The Reference Approach (RA) is a top-down approach, using a country's energy supply data to calculate the CO_2 emissions from mainly fossil fuels combustion. The RA is a straightforward method that can be applied on the basis of relatively easily available energy supply statistics. Excluded carbon has increased the requirements for data to some extent. However, improved comparability between the sectorial and reference approaches continues to allow a country to produce a second independent estimate of CO_2 emissions from fuel combustion with limited additional effort and data requirements (IPCC, 2006 p. 6.5). The RA is designed to calculate the emissions of CO_2 from fuel combustion, starting from high level energy supply data. The assumption is that carbon is conserved so that, for example, carbon in crude oil is equal to the total carbon content of all the derived products. The RA does not distinguish between different source categories within the energy sector and only total CO_2 emissions from source category fuel combustion (1.A) (IPCC, 2006 p. 6.5).

The RA has been executed for the entire time series from 1990 until 2020. The basis for this is essentially provided by the numbers for the national energy balances on primary energy consumption, but in the case of Mongolia it is provided by coal balances of national and IEA statistics.

The results of the RA are summarized and compared with Sectoral Approach (SA) in the Tables 3-22⇢ 3-24 below. The difference of energy consumption for total fuels between the RA and SA gives an average deviation of -0.04% over all years and the average difference of CO_2 emissions between RA and SA is -0.66% over all years. Based on the IPCC methodology, RA in apparent consumption of fuels was estimated after consideration of carbon stored in iron and steel industry. Figure 3-8 shows the CO_2 emissions calculated by two approaches and Figure 3-9 shows the percentage differences in energy consumption and CO_2 emissions of two approaches with a standard error of ±5% or less (red lines) according to the 2006 IPCC GLs.

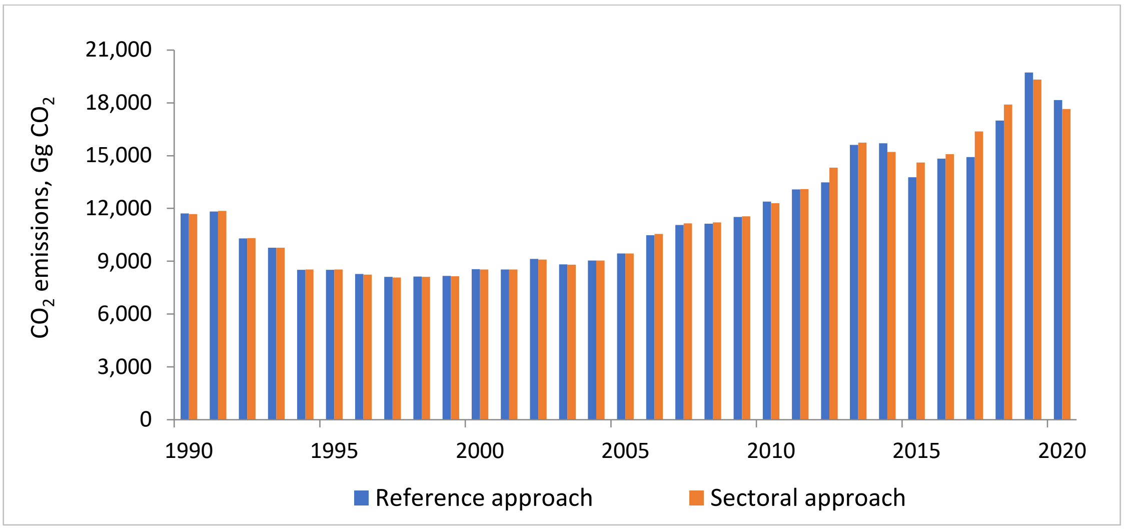

Figure 3-8: Total fuels CO_2 emissions differences between RA and SA in Gg CO_2

From Figure 3-9 can be seen that the differences of CO_2 emissions in 2012, 2015 and 2017 exceeded from ±5% limit. The reasons for the differences between the two approaches lie on the large statistical differences in national statistical data, missing information on combustion of certain transformation outputs and simplification in the RA. There are small quantities of carbon which should be included in the RA because their emissions fall under fuel combustion. These quantities have been excluded where flows are small or not represented by a major statistic available within energy data.

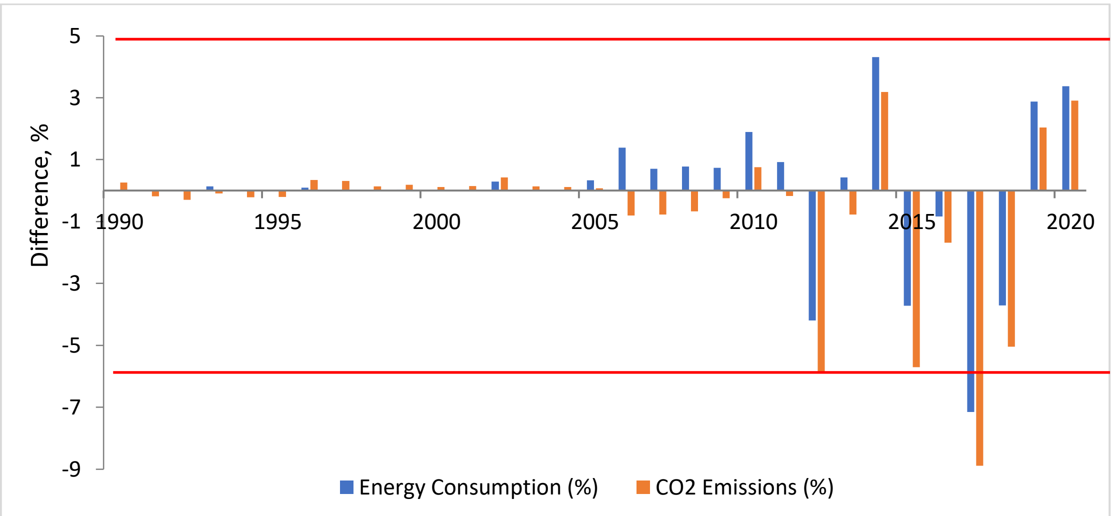

Figure 3-9: Total fuels energy consumption and CO_2 emissions differences between RA and SA, %

The data input to the IPCC software is checked thoroughly for mistyping, but there are large differences in fuel stock changes, and in some cases, there are uncertain numbers of fuel consumption allocations in the coal balance tables. The fuel consumption allocation in the coal balance tables should be checked by sectoral experts and the uncertainties and differences should be eliminated as possible in the future.

Table 3-22: Comparison of total fuel consumption and CO_2 emissions between RA and SA for the period 1990-2020

TOTAL FUELS						
	Apparent Energy Consumption			*CO_2 emissions*		
Year	*RA*	*SA*	*Difference*	*RA*	*SA*	*Difference*
	(TJ)	*(TJ)*	*(%)*	*CO_2 (Gg)*	*CO_2 (Gg)*	*(%)*
1990	130,191.67	130,191.66	0.00	11,715.40	11,685.58	0.26
1991	132,292.42	132,292.42	0.00	11,833.08	11,855.10	-0.19
1992	114,629.34	114,629.38	0.00	10,293.73	10,324.37	-0.30
1993	109,262.06	109,117.79	0.13	9,763.89	9,773.26	-0.10
1994	94,265.67	94,265.67	0.00	8,512.87	8,531.20	-0.21
1995	94,189.25	94,189.21	0.00	8,519.91	8,537.47	-0.21
1996	89,391.44	89,305.31	0.10	8,276.65	8,248.56	0.34
1997	87,597.27	87,597.21	0.00	8,113.10	8,087.75	0.31
1998	88,154.52	88,154.52	0.00	8,131.19	8,119.78	0.14
1999	88,561.53	88,542.57	0.02	8,173.64	8,158.33	0.19
2000	92,928.39	92,928.44	0.00	8,552.22	8,542.02	0.12
2001	92,868.80	92,868.86	0.00	8,542.01	8,529.37	0.15
2002	99,353.51	99,064.54	0.29	9,137.47	9,098.70	0.43
2003	96,622.92	96,622.91	0.00	8,828.51	8,816.28	0.14
2004	99,515.58	99,515.58	0.00	9,053.18	9,042.94	0.11
2005	105,507.55	105,160.50	0.33	9,451.86	9,445.26	0.07
2006	118,933.60	117,301.87	1.39	10,476.49	10,562.05	-0.81
2007	125,956.67	125,071.46	0.71	11,063.78	11,150.28	-0.78
2008	127,033.24	126,048.21	0.78	11,132.23	11,207.83	-0.67
2009	130,445.20	129,489.05	0.74	11,518.25	11,547.31	-0.25
2010	139,856.52	137,260.37	1.89	12,392.86	12,300.49	0.75
2011	149,901.14	148,537.21	0.92	13,075.86	13,098.98	-0.18
2012	155,881.85	162,714.10	-4.20	13,474.73	14,311.79	-5.85
2013	178,608.72	177,845.20	0.43	15,609.28	15,731.68	-0.78
2014	179,364.10	171,944.01	4.32	15,696.92	15,212.89	3.18
2015	159,216.71	165,364.95	-3.72	13,775.08	14,607.95	-5.70
2016	167,969.70	169,387.28	-0.84	14,821.88	15,075.08	-1.68
2017	172,152.60	185,427.18	-7.16	14,911.04	16,365.91	-8.89
2018	194,970.55	202,482.73	-3.71	16,993.22	17,896.06	-5.04
2019	227,269.39	220,917.44	2.88	19,714.60	19,321.74	2.03
2020	209,817.67	202,974.28	3.37	18,161.87	17,649.30	2.90

Table 3-23: Comparison of solid fuel consumption and CO_2 emissions between RA and SA for the period 1990-2020

SOLID FUELS						
	Apparent Energy Consumption			*CO_2 emissions*		
Year	*RA*	*SA*	*Difference*	*RA*	*SA*	*Difference*
	(TJ)	*(TJ)*	*(%)*	*CO_2 (Gg)*	*CO_2 (Gg)*	*(%)*
1990	97,946.57	97,946.56	0.00	9,386.68	9,356.26	0.33
1991	108,824.50	108,824.50	0.00	10,128.89	10,150.44	-0.21
1992	96,794.68	96,794.68	0.00	9,009.18	9,039.53	-0.34
1993	87,366.54	87,366.54	0.00	8,170.16	8,190.22	-0.24
1994	79,419.33	79,419.33	0.00	7,440.88	7,458.96	-0.24
1995	79,711.37	79,711.34	0.00	7,481.89	7,499.25	-0.23
1996	74,253.88	74,253.88	0.00	7,190.84	7,169.20	0.30
1997	72,732.31	72,732.30	0.00	7,044.39	7,018.81	0.36
1998	72,034.55	72,034.55	0.00	6,976.31	6,964.66	0.17
1999	72,507.06	72,488.05	0.03	7,020.78	7,005.21	0.22
2000	75,311.75	75,311.75	0.00	7,293.09	7,282.63	0.14
2001	74,987.90	74,987.91	0.00	7,261.28	7,248.36	0.18

2002	80,266.07	79,977.10	0.36	7,772.20	7,733.15	0.50
2003	75,744.02	75,744.00	0.00	7,333.47	7,320.92	0.17
2004	76,441.18	76,441.18	0.00	7,397.78	7,387.17	0.14
2005	82,854.90	82,507.85	0.42	7,825.32	7,818.33	0.09
2006	93,146.07	91,514.38	1.78	8,624.17	8,709.29	-0.98
2007	94,019.28	93,134.07	0.95	8,768.45	8,854.40	-0.97
2008	92,749.72	91,764.73	1.07	8,667.03	8,742.03	-0.86
2009	98,964.51	98,008.32	0.98	9,251.18	9,279.65	-0.31
2010	106,457.29	103,861.13	2.50	9,976.19	9,883.12	0.94
2011	108,346.98	106,983.10	1.27	10,063.40	10,085.61	-0.22
2012	108,639.68	115,471.93	-5.92	10,054.79	10,890.84	-7.68
2013	129,297.16	128,533.64	0.59	12,034.55	12,155.87	-1.00
2014	132,509.98	125,089.89	5.93	12,310.68	11,825.69	4.10
2015	109,239.84	119,030.11	-8.23	10,163.87	11,262.91	-9.76
2016	128,223.94	129,641.51	-1.09	11,955.87	12,208.30	-2.07
2017	120,449.99	133,724.53	-9.93	11,165.03	12,618.78	-11.52
2018	140,168.52	147,680.70	-5.09	13,023.00	13,924.65	-6.48
2019	158,190.28	151,838.28	4.18	14,708.43	14,314.05	2.76
2020	141,731.19	134,887.81	5.07	13,236.62	12,722.61	4.04

Table 3-24: Comparison of liquid fuel consumption and CO_2 emissions between Ra and SA for the period 1990-2020

LIQUID FUELS						
	Apparent Energy Consumption			*CO_2 emissions*		
Year	*RA (TJ)*	*SA (TJ)*	*Difference (%)*	*RA CO_2 (Gg)*	*SA CO_2 (Gg)*	*Difference (%)*
1990	32,245.10	32,245.10	0.00	2,328.72	2,329.32	-0.03
1991	23,467.92	23,467.92	0.00	1,704.19	1,704.66	-0.03
1992	17,834.65	17,834.70	0.00	1,284.55	1,284.85	-0.02
1993	21,895.52	21,895.52	0.00	1,593.73	1,594.20	-0.03
1994	14,846.33	14,846.33	0.00	1,071.99	1,072.24	-0.02
1995	14,477.88	14,477.88	0.00	1,038.02	1,038.22	-0.02
1996	15,137.56	15,137.56	0.00	1,085.81	1,086.03	-0.02
1997	14,864.96	14,864.91	0.00	1,068.71	1,068.94	-0.02
1998	16,119.97	16,119.97	0.00	1,154.89	1,155.11	-0.02
1999	16,054.48	16,054.52	0.00	1,152.86	1,153.12	-0.02
2000	17,616.64	17,616.69	0.00	1,259.14	1,259.39	-0.02
2001	17,880.91	17,880.95	0.00	1,280.74	1,281.01	-0.02
2002	19,087.44	19,087.44	0.00	1,365.27	1,365.55	-0.02
2003	20,878.90	20,878.90	0.00	1,495.04	1,495.36	-0.02
2004	23,074.41	23,074.41	0.00	1,655.39	1,655.77	-0.02
2005	22,652.65	22,652.65	0.00	1,626.54	1,626.92	-0.02
2006	25,787.53	25,787.49	0.00	1,852.33	1,852.76	-0.02
2007	31,937.39	31,937.39	0.00	2,295.33	2,295.89	-0.02
2008	34,283.52	34,283.48	0.00	2,465.20	2,465.80	-0.02
2009	31,480.69	31,480.73	0.00	2,267.07	2,267.66	-0.03
2010	33,399.24	33,399.24	0.00	2,416.67	2,417.37	-0.03
2011	41,554.15	41,554.11	0.00	3,012.46	3,013.37	-0.03
2012	47,242.17	47,242.17	0.00	3,419.94	3,420.94	-0.03
2013	49,311.56	49,311.56	0.00	3,574.73	3,575.81	-0.03
2014	46,854.12	46,854.12	0.00	3,386.24	3,387.20	-0.03
2015	46,334.88	46,334.84	0.00	3,344.13	3,345.04	-0.03
2016	39,745.76	39,745.76	0.00	2,866.01	2,866.78	-0.03
2017	51,702.61	51,702.66	0.00	3,746.00	3,747.13	-0.03
2018	54,802.02	54,802.03	0.00	3,970.22	3,971.41	-0.03
2019	69,079.11	69,079.16	0.00	5,006.17	5,007.68	-0.03
2020	68,086.47	68,086.47	0.00	4,925.25	4,926.69	-0.03

According to the improvement plan developed after the submission of iBUR (2017), the examination of differences between results of the sectoral (SA) and the reference approaches (RA) had been performed by experts within the *"Capacity development to establish a national GHG inventory cycle of continuous improvement"* project by JICA (2017-2022). The difference of more than 5% was occurring in some years (e.g., 1997, 1999, 2006). The reasons were mistyping the figures and using the different EFs in both approaches: the consumption of sub-bituminous coal is 161.8 TJ in SA, while 0 TJ in RA (year 1997); for lignite the country-specific EF 77,900 kg CO_2/TJ was used in SA, while the default EF 101,000 kg CO_2/TJ was used in RA. These errors were corrected for the BUR2, but there are still the differences due to statistical differences and losses during transportation and storage in the coal balance table of NSO, e.g., starting from 2005 the distribution losses have been recorded and these are not inputted in the SA; starting from 2006 coke oven coke (COC) and coke oven gas (COG) are been produced as by-products of coking coal transformation and the figures were inputted in the SA, but not in RA; starting from 2011 occurred a coal consumption in the processing industries on NSO's coal balance table and these figures were not included in both approaches. Such issues cause the discrepancies between two approaches and hence should be constantly improved in further submissions.

3.2.7 International bunkers (1.A.3.a.i)

This category includes emissions from the international aviation (1.A.3.a.i). These emissions are excluded from the national totals and reported as a memo item. Mongolia has estimated emissions from international bunkers using the Tier 1 method of the 2006 IPCC GLs. Due to the unavailability or lack of fuel consumption data, an expert assumption has been made for domestic and international fuel consumptions. In general, it is difficult to split the fuel consumption between domestic and international flights. The GHG emissions from international bunkers have been estimated based on the imported jet fuel, derived from national statistics. All imported jet fuel was assumed to be consumed within the inventory year. An expert assumption was made in the jet fuel consumption of both domestic and international aviation. The annual refueling information for domestic and international flights was taken from the Mongolian Civil Aviation Authority (MCAA) statistics for 2018 and 2019. Using this information, the average share of jet fuel consumption was estimated at 50% for international and 50% for domestic flights. Therefore, jet fuel consumption for entire time series was estimated from imported fuel information. The jet fuel consumption data for domestic and international flights should be improved for further submissions.

Since the jet kerosene is imported from Russia, the IPCC default values were used for GHG emissions calculations (Table 3-25). The IPCC default values were taken from the 2006 IPCC GLs, Vol. 2, Ch. 3, Table 3.6.4 and 3.6.5, p. 3.64.

Table 3-25: GHG emissions from international aviation bunkers for the period 1990-2020, Gg CO_2e

Category	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Non-specified	676.77	168.68	593.94	228.02	246.04	460.02	511.11	168.68	161.78	346.80	138.42
	2001	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
	442.27	189.61	316.64	262.85	210.64	366.13	256.00	276.44	536.47	416.49	630.16
	2012	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*		
	702.27	824.79	765.34	486.45	1,009.75	722.34	1,213.93	1,853.04	903.51		

GHG emission trend in the international aviation bunkers can be seen from Figure 3-10. Emissions in 2020 are relatively low compared to the previous year, most likely due to global Covid-19 pandemic restrictions.

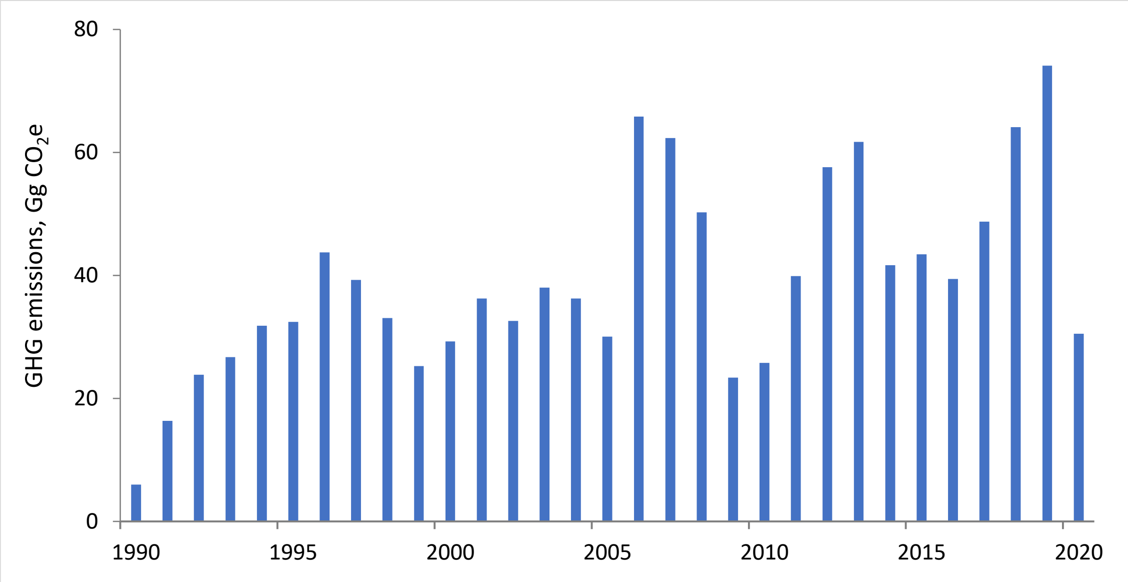

Figure 3-10: GHG emission trend in the international aviation bunkers, Gg CO_2e

There are two major rises and declines in the trend of GHG emissions in international aviation bunkers. On the one hand along the economic growth and downturn international and domestic flight numbers are changing and this has an influence to the GHG emissions in this sector. The sharp rise from 2005 to 2006 caused by:

- Eznis Airways LLC was established on January 6th 2006 with the investment of Newcom Group which is one the biggest groups in Mongolia, and imported the airplane SAAB-340B which was produced in Sweden and officially operated for the domestic flights. Thus the domestic flight number has been increased.
- In 2006 total passenger transportation increased by 16% than previous year.

The sharp decline from 2008 to 2009 caused by:

- World economic downturn,
- Growth of the U.S. dollar compared to national currency,
- Increase of fuel prices,
- "Aero Mongolia LLC" stopped its operation for the domestic flights due to lack of aircraft and was suspended in 2009,
- Due to these reasons the passenger transportation decreased by 11%.

Although it is complicated to distinguish the fuel consumption data between domestic and international, Mongolia should make efforts to collect and improve data, and in line ministry and Mongolian Civil Aviation Authority should support it.

3.2.8 Feedstock and non-energy use of fuels

For a number of applications, mainly in larger industrial processes, fossil hydrocarbons are not only used as energy sources, but also have other uses e.g. feedstock, lubricants, solvents, etc. The sectorial approaches (Tier 1, 2 and 3) are therefore based on fuel combustion statistics.

In the case of Mongolia, the lubricants use has been reported in the Industrial Processes and Product Use (IPPU) sector under Non-energy products from fuels and solvent use (2.D) source category, not under fuel combustion category (1.A) in the energy sector.

3.3 Fugitive emissions from solid fuels (1.B)

3.3.1 Category description

In Mongolia the fugitive emissions from fuels occur in the coal mining and handling and oil industries. Mongolia does not have yet any petroleum refining industries. The fugitive emissions from fuels were calculated from the surface mining industry, because the underground mines are not occurring in Mongolia. Coal production in Mongolia was steadily increasing until 2019, but due to the Covid-19 pandemic it has been decreased in 2020 compared to 2019.

The crude oil production has been started from 1996 in Mongolia and amount of explored oil was around 2.0 thousand cubic meters, and in 2020 it was 1.2 million cubic meters. Approximately 5.9 million tonnes of oil was explored in Mongolia between 1996 and 2016. The explored crude oil is exported directly to China. There are three major oil fields in Mongolia, namely Toson-Uul XIX (field name); Tamsag XXI which are located in Dornod province of Mongolia and operated by PetroChina Daqing Tamsag LLC; and Tsagaan els which is located in Dornogobi province and operated by Dongsheng Petroleum LLC (MRPAM, 2017). Crude oil production sharply and steadily increased until 2015 and then gradually declined until 2020. Due to the decrease in the number of oil exploration license holders, as well as the decrease in oil demand and prices in the global oil market, the amount of crude oil production in Mongolia has decreased in recent years.

The overview of total fugitive emissions from fuels has been presented in Figure 3-11.

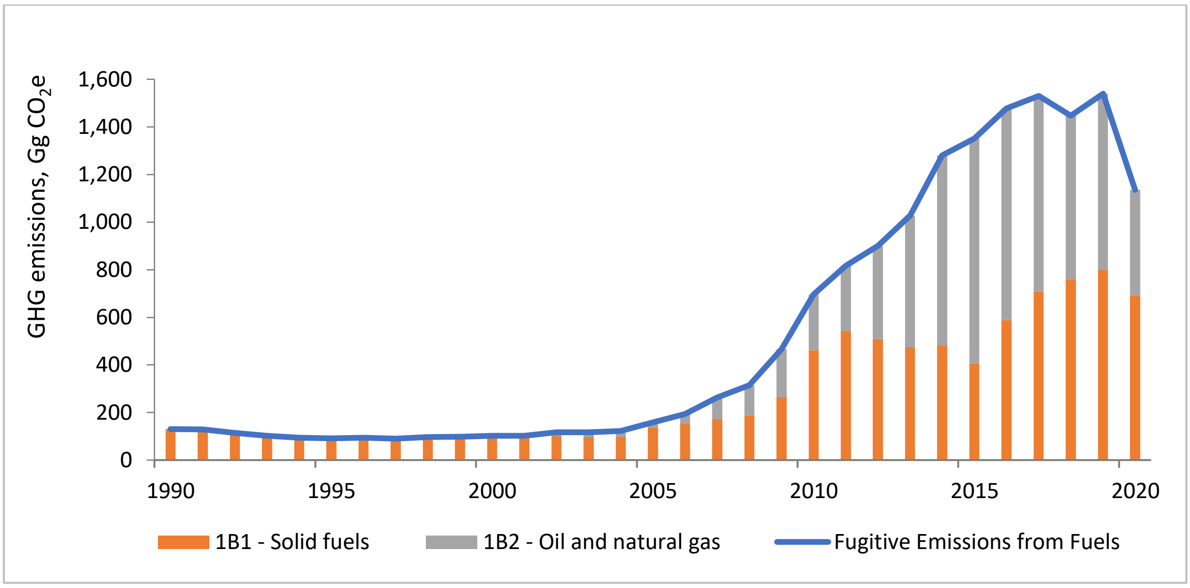

Figure 3-11: GHG emission trend in the fugitive emissions from fuels, Gg CO_2e

Total emissions from fugitive emissions are shown in Table 3-26. Although the line ministry and MRPAM assert that crude oil production started in 1996, the amount was negligible, and the production activities were not regularized. Only since 1998 the production amount of crude oil has started to be registered in the national statistics. Therefore, figures starting from 1990 until 1998 reported as a not occurring (NO).

Table 3-26: Total fugitive emissions from fuels, Gg CO_2e

Years	*Solid fuels - Surface coal mining and handling*	*Oil and natural gas - Oil*	*TOTAL FUGITIVE EMISSIONS FROM FUELS*
1990	130.91	NO	130.91
1991	128.71	NO	128.71
1992	114.26	NO	114.26
1993	102.74	NO	102.74
1994	94.35	NO	94.35
1995	91.80	NO	91.80
1996	93.47	NO	93.47
1997	90.06	NO	90.06
1998	92.50	4.85	97.35
1999	90.80	7.87	98.67
2000	94.84	7.09	101.92
2001	94.03	7.87	101.91
2002	101.41	14.94	116.35
2003	97.11	19.68	116.79
2004	98.77	23.61	122.38
2005	137.47	21.24	158.71
2006	152.91	40.92	193.83
2007	172.48	91.29	263.77
2008	187.81	126.70	314.51
2009	264.30	201.45	465.75
2010	461.17	235.30	696.47
2011	541.34	275.43	816.77
2012	508.95	391.88	900.83
2013	474.60	553.21	1,027.80
2014	482.22	797.94	1,280.16
2015	406.34	945.09	1,351.43
2016	588.35	889.23	1,477.58
2017	708.63	821.87	1,530.50
2018	757.93	688.68	1,446.61
2019	799.30	741.24	1,540.54
2020	692.75	442.61	1,135.36

3.3.2 Methodological issues

3.3.2.1 Choice of the method

This source category covered fugitive emissions from surface coal mining and handling, because there are no underground mines existing. In 1980s' there was a Nalaikh underground mine, which was closed in the early 1990s' after victory of the democratic revolution. The data on abandoned mine were not available and emissions were not calculated from this subcategory. The Tier 1 method is used for emissions calculations.

The fundamental equation (Tier 1) for emissions estimation from surface coal mining is shown below.

$$CO_4\ Emissions = Surface\ mining\ emissions\ of\ CH_4 + Post\text{-}mining\ emission\ of\ CH_4$$

To estimate emissions from surface mining there is needed the total amount of coal produced in the country in "t/year" unit, multiplied with CH_4 EF in "m^3/t" unit and multiplied with conversion factor in "Gg CH_4/m^3" unit.

Regarding the oil, fugitive emissions from flaring of natural gas and waste gas/vapor streams at oil production facilities, and fugitive emissions from oil production and upgrading activities were covered.

Fugitive emissions from other oil activities such as exploration, transport, refining activities and distribution of oil products were not estimated due to lack of data or even the activity, e.g. oil refining, is not occurring in Mongolia. Since Mongolia does not have an oil refinery and imports the oil products from Russia.

Mongolia is not a natural gas producing country, domestic natural gas is imported from other countries.

3.3.2.1.1 Activity data

The coal and crude oil production data were obtained from NSO and cross-checked with IEA balances data. The activity data for coal mining activities should be obtained in "kt" unit and the activity data for crude oil in "m^3" unit.

3.3.2.1.2 Emission factors and other parameters

Since the Tier 1 method was used, the IPCC default values for CO_2 and CH_4 emission factors (EFs). According to the 2006 IPCC GLs, it is a *good practice* to use the low end of the specific emission range for those mines with average overburden depths of less than 25 meters and the high end for overburden depths over 50 meters for the Tier 1 method. In the absence of data on overburden thickness, it is *good practice* to use the average EF, namely 1.2 m^3/t.

So this way the default CH_4 EF for mining emissions was chosen as a value of 1.2 m^3/t for average mining depth from the 2006 IPCC GLs, Vol. 2, Ch. 4, p. 4.18. The conversion factor was taken from the same source as a value of $0.67*10^{-6}$ Gg/m^3.

Default EF for post-mining emissions was chosen as the CH_4 EF for average mining depth as a value of 0.1 m^3/t. The conversion factor has a value of $0.67*10^{-6}$ Gg/m^3 (the 2006 IPCC GLs, Vol. 2, Ch. 4, p.4.19). According to the 2006 IPCC GLs, the average emission and conversion factors should be used unless there is country-specific evidence to support use of the low or high emission and conversion factors.

3.3.2.2 Category-specific recalculations

The source of activity data has changed, i.e. the data collection of the energy balance tables from the IEA statistics was in "TJ" units and should be converted into "kt" units. Therefore, a recalculation was conducted for entire time series from 1990 until 2020.

3.3.2.3 Category-specific planned improvements

As mentioned above there are several other sources for estimating fugitive emissions from fuels, and the activity data from these sources need to be obtained, analyzed and improved in the future.

In particular, it is important to make efforts to collect the activity data for fugitive emissions from the transport and distribution of oil products, as this source category is a key category as calculated and reported in previous iBUR.

The oil refinery is currently under construction, and once the refinery is commissioned (expected in 2025) and operational, the activity data collection will begin and so the emissions will be calculated in subsequent submissions.

CHAPTER 4: INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)

4.1 Overview of sector

The GHG emissions of IPPU sector estimated from Mineral industry (2.A), Metal industry (2.C), Non-energy products from fuels and solvent use (2.D), and Product uses as substitutes for ozone depleting substances (2.F). The rest of the activities under IPPU sector were excluded from the inventory because they either do not occur in Mongolia or there was no sufficient data to use. For example, the chemical and electronics industries are not occurring in Mongolia. The main contributors to the total emissions from IPPU sector are the Mineral industry (cement and lime production) which emitted the CO_2 and the Product uses as substitutes for ozone depleting substances the HFCs. Figure 4-1 shows the share of IPPU sector with 2.66% of the national total emissions in 2020.

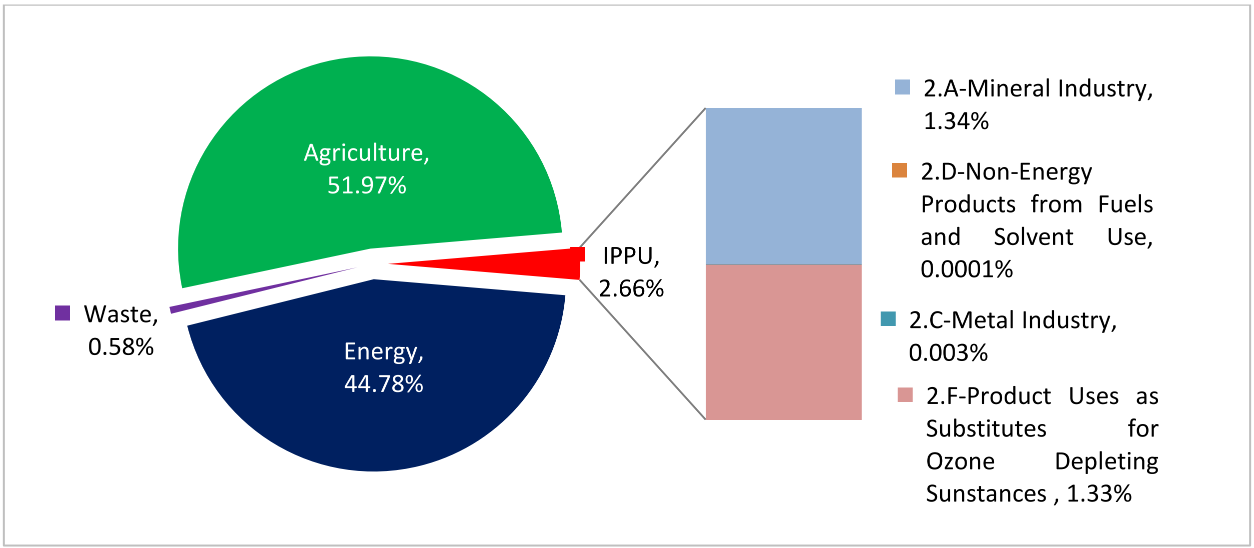

Figure 4-1: Share of each subsector of IPPU sector in total national GHG emissions (excl. LULUCF), 2020

In 2020, total GHG emissions of IPPU were 1,147.75 Gg CO_2e, it shows the emissions increased by 302.75% compared to 1990.

Table 4-1: GHG emissions from IPPU by source categories in 1990 and 2020

Source categories	*Gas*	*Emissions, Gg CO_2e*		*Change from 1990 (Gg CO_2e)*	*Change from 1990 (%)*
		1990	*2020*		
2.A.- Mineral Industry	CO_2	272.08	575.18	303.10	111.40%
3.C - Metal Industry	CO_2	NA	1.22	-	-
2.D -Non-energy Products from Fuels and Solvent Use	CO_2	12.89	0.04	-12.85	-99.69%
2.F- Product Uses as Substitutes for Ozone Depleting Substances	CO_2	NA	571.30	-	-
2. IPPU Total	CO_2	284.98	1,147.75	862.77	302.75 %

Abbreviations: NA-Not applicable

In Table 4-2, the main contributor to the total emissions of the sector was a Mineral industry and it contributed 50.11% to the total emissions of the IPPU sector in 2020. The second highest contributor to the total emissions of the sector was Product uses as substitutes for ozone depleting substances and it represented 49.78% in 2020. The rest two subsectors, Metal industry and Non-energy products from fuels and solvent use contributed a miner share with 0.11 and 0.004 to the total emissions of the sector in 2020 respectively.

Table 4-2: GHG emissions from IPPU by source categories, Gg CO_2e

Source categories	*Unit*	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*
2.A - Mineral Industry	Gg CO_2e	272.08	86.64	68.28	110.36	180.20	220.49	575.18
	%	95.48	97.89	96.78	94.46	80.86	67.52	50.11
2.C - Metal Industry	Gg CO_2e	NA	1.25	1.04	5.24	5.1	3.50	1.22
	%	NA	1.41	1.47	4.49	2.30	1.07	0.11
2.D - Non-energy Products from Fuels and Solvent Use	Gg CO_2e	12.89	0.62	1.23	1.23	1.85	0.62	0.04
	%	4.52	0.70	1.75	1.05	0.83	0.19	0.004
2.F - Product Uses as Substitutes for Ozone Depleting Substances	Gg CO_2e	NA	NA	NA	NA	35.67	101.97	571.30
	%	NA	NA	NA	NA	16.01	31.23	49.78
2. IPPU Total	Gg CO_2e	284.98	88.50	70.55	116.83	222.85	326.58	1147.75
	%	100	100	100	100	100	100	100

The metal industry production was launched in 1995 thus, GHG emissions from the sector were not estimated for the period of 1990-1994. However, the activity data of product uses as substitutes for ozone depleting substances became available from 2012, according to the 2006 IPCC GLs, Vol.3, Part 2, if there is Tier 1 method was applied for estimation of HFCs emissions, then it back-calculates the development of banks of a refrigerant from the current reporting year to the introduction year. The introduction year for HFC-134a (mobile air conditioning) is 2007.

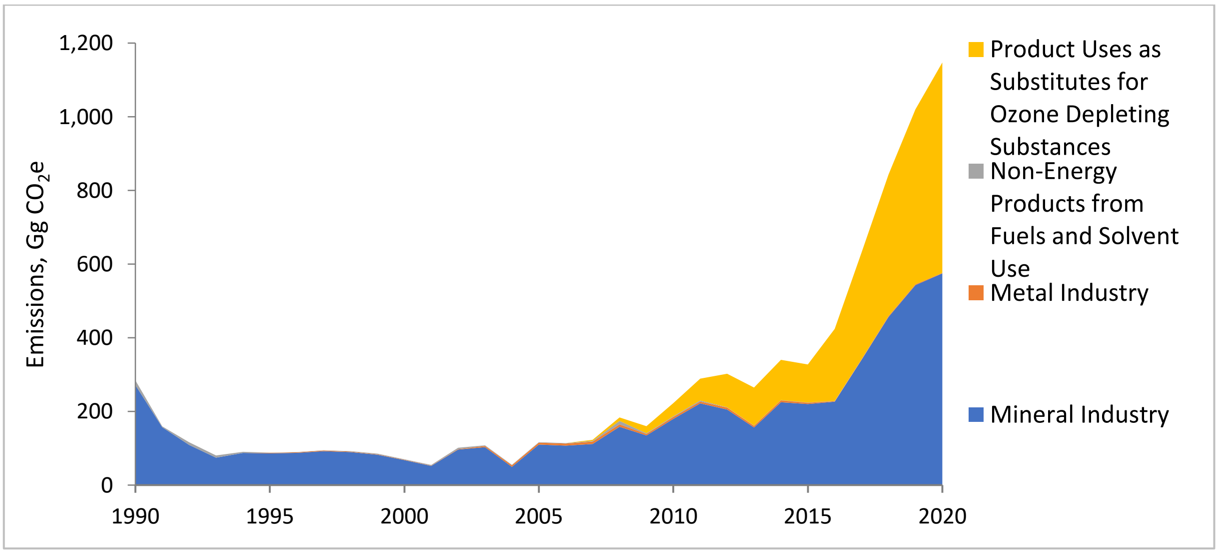

Figure 4-2: GHG emissions from IPPU sector by source categories, Gg CO_2e

Figure 4-2 shows emissions from IPPU sector demonstrated year-by-year variations during the 1990-2020 time series, however GHG emissions from IPPU sector continuously increased since 2015. From 2008-2009 there was an economic downturn in Mongolia and after this in 2010 the economy has grown back.

The emissions from Mineral industry significantly increased since 2014 (Table 4-3). In Mongolia there are two main cement plants operating namely Darkhan cement plant, built in 1968 and "Cement and Lime" plant, built in 1983. The processing technology of both plants changed from wet to dry in 2014, with generating capacity of 1 million tonnes of cement per year. The total GHG emissions of IPPU sector had increased sharply since 2016, due to the growth of consumption of Products uses as substitutes for ozone depleting substances.

Table 4-3: The aggregated GHG emissions of IPPU sector by source categories, 1990-2020, Gg CO_2e

Year	2.A-Mineral industry	2.C-Metal industry	2.D-Non-energy products from fuels and solvent use	2.F-Product uses as substitutes for ozone depleting substances	2. IPPU Total
1990	272.08	NA	12.89	NA	284.98
1991	157.47	NA	2.45	NA	159.92
1992	109.42	NA	7.36	NA	116.78
1993	74.78	NA	6.15	NA	80.92
1994	87.72	NA	3.07	NA	90.79
1995	86.64	1.25	0.62	NA	88.50
1996	87.88	1.54	0.62	NA	90.03
1997	92.53	1.82	0.62	NA	94.96
1998	90.03	1.30	1.23	NA	92.56
1999	82.95	1.05	1.85	NA	85.84
2000	68.28	1.04	1.23	NA	70.55
2001	52.50	0.80	1.85	NA	55.15
2002	96.89	1.27	3.68	NA	101.84
2003	103.39	3.14	1.85	NA	108.38
2004	49.86	4.39	1.23	NA	55.48
2005	110.36	5.24	1.23	NA	116.83
2006	107.53	5.60	1.23	NA	114.36
2007	111.99	6.43	1.85	3.10	123.37
2008	158.71	6.51	1.85	9.45	176.51
2009	135.18	4.01	1.85	19.27	160.31
2010	180.20	5.14	1.85	35.67	222.85
2011	222.18	4.80	3.07	59.09	289.13
2012	205.54	5.45	0.62	90.52	302.13
2013	156.91	4.48	0.62	102.30	264.31
2014	225.29	5.15	0.62	108.22	339.28
2015	220.49	3.50	0.62	101.97	326.58
2016	226.82	1.34	0.62	194.18	422.96
2017	340.59	1.68	0.31	288.09	630.67
2018	456.76	2.34	0.25	382.53	841.88
2019	543.29	2.29	0.06	473.17	1018.81
2020	575.18	1.22	0.04	571.30	1147.75
Diff. % 1990/2020	111.40	-	-99.69	-	302.75
Diff. % 2019/2020	5.86	-46.7	-33.3	20.7	12.6

Abbreviations: NA-Not applicable

The GHG emissions of Mineral industry in 2020 increased by 111.40% compared to the base year and it increased by 5.86 % compared to 2019. The emissions from Metal industry in 2020 decreased by 46.7 % compared to 2019. The emissions from Non-energy products from fuels and solvent use in 2020 decreased by 99.69 % compared to the base year and it shows 33.3 % decrease compared to 2019. The emissions of Product uses as substitutes for ozone depleting substances in 2020 significantly increased by 302.75 % compared to the base year and it increased by 12.6 % compared to 2019 respectively.

4.1.1 Methodological issues

IPPU sector of the National GHG inventory estimation was conducted using the 2006 IPCC GLs for National Greenhouse Gas Inventories and software. Tier 1 method, default emission factors (EFs) was used for the GHG emissions estimation from IPPU sector.

Table 4-4: Summary of methods used to estimate GHG emissions for the IPPU sector

IPCC Code	*Source categories*	*CO_2*		*HFCs*	
		Method	*EF*	*Method*	*EF*
2.A	Mineral Industry	T1	D	-	-
2.A.1	Cement Production	T1	D	-	-
2.A.2	Lime Production	T1	D	-	-
2.C	Metal Industry	T1	D	-	-
2.C.1	Iron and Steel Production	T1	D	-	-
2.D	Non-energy Products from Fuels and Solvent Use	T1	D	-	-
2.D.1	Lubricant Use	T1	D	-	-
2.F	Product Uses as Substitutes for Ozone Depleting Substances	-	-	T1	D
2.F.1	Refrigeration and Air conditioning	-	-	T1	D
2.F.2	Foam Blowing Agents	-	-	T1	D
2.F.3	Fire Protection	-	-	T1	D
2.F.4	Aerosols	-	-	T1	D

Abbreviations: T1-Tier 1 method; EF-Emission factors.

4.1.2 Key categories

The key categories of the IPPU sector (excluding LULUCF) in 2020 by level and trend are presented in Table 4-5. These key categories were selected from an overall key category analysis conducted using the Tier 1 method. Emissions from cement production were included in both level and trend assessment and the emissions from Lime production and Refrigeration and air conditioning were included in trend assessment as key source categories. More detailed information is provided in Annex II.

Table 4-5: Key Categories Analysis under the IPPU sector

IPCC code	*Source categories*	*GHG*	*Key Categories*
2.A.1	Cement Production	CO_2	Yes (L,T)
2.A.2	Lime Production	CO_2	Yes (T)
2.F.1	Refrigeration and Air Conditioning	HFCs	Yes (T)

Abbreviations: L-Level; T-Trend

4.1.3 Uncertainties assessment and time series consistency

Uncertainties related to estimation of CO_2 and HFCs emissions from the IPPU sector, in general, depend on the accuracy of main source of activity data and application of emission factors, especially, when default values are used. In this sector, the IPCC default uncertainty values for activity data and emission factors have been used, if applicable. However, the expert judgment was performed to choose values applicable for GHG emission calculations from this sector. All calculated uncertainties of emission factors and activity data used are in accordance with methodology used in emission estimations, derived from the 2006 IPCC GLs and detailed uncertainty values used in uncertainty assessment are presented under the source categories. Results from uncertainty estimates from all categories can be seen in Annex III.

The time series was checked for the consistency. In next iteration, investigation will be performed with a view to collect more accurate data.

4.1.4 Quality assurance and Quality control (QA/QC)

Under the 2006 IPCC GLs, Vol. 1, Ch. 6 the quality control (QC) has been done by the inventory team. Sector specific QA/QC plan is based on the general QA/QC rules and activities in specific categories. The sector specific QC activities were performed directly during the GHG emissions calculation (the GHG emissions calculation has been done by the 2006 IPCC Inventory Software) such as checking several data sources and data inputs into the software, including the QC for the

EFs and other parameters as well. The main source of activity data of GHG emissions estimation is the National statistics office of Mongolia (NSO). Generally the NSO collects and consolidates data from organizations/ institutions and producers by questionnaires at national level. For the activity data collection of GHG emissions estimation the questionnaires, in the form of official letters, were sent to the relevant government and private organizations/ institutions in order to compare and ensure with data from NSO. The data collected and published by NSO from the relevant government and private organizations/institutions, in most cases differ from the data directly provided by those organizations/institutions. The data from Statistical yearbooks and relevant stakeholders such as Ministry of Mining and Heavy Industry (MMHI), were cross-checked. The 2006 IPCC GLs recommends if there is availability of several sources of the activity data. Generally, it's a good practice to follow the data from national statistics.

4.1.5 Source specific recalculations

Recalculations were made due to some activity data were updated from NSO and relevant data suppliers. The changes of GHG emissions estimations from IPPU sector can be explained as follows:

1. In previous GHG inventory (during iBUR) the GHG emissions have been calculated from:

- CO_2 emissions from clinker production,
- CO_2 emissions from steel bloom production (for metal industry – iron and steel production),
- CO_2 emissions from lubricant use (for non-energy products from fuels and solvent use),
- HFCs consumption data from report titled "Report for HFCs inventory and identification of opportunities for introduction of low-GWP alternatives in Mongolia" done by NOA. (activity data for consumption of HFCs were available from 2012).

2. In this GHG inventory (during BUR2) the GHG emissions have been calculated from:

- CO_2 emissions from cement production,
- CO_2 emissions from steel bloom production (for metal industry – iron and steel production),
- CO_2 emissions from lubricant use (for non-energy products from fuels and solvent use),
- HFCs emissions from consumption data provided from "Report for HFCs inventory and identification of opportunities for introduction of low-GWP alternatives in Mongolia" and "Ozone-Depleting substance alternatives survey and HFC inventory report" done by NOA (activity data for consumption of HFCs were available from 2012).

The default EFs were used for both emissions calculations. Table 4-6 shows the recalculated GHG emissions of the Second Biennial Update Report (BUR2) compared to initial Biennial Update Report (iBUR) of Mongolia.

Table 4-6: Recalculated GHG emissions under the IPPU sector for 1990-2020, included in the iBUR and BUR2 of the Mongolia, Gg CO_2e

Year	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
iBUR	218.66	144.23	107.57	70.15	83.71	82.81	82.26	86.95	84.09
BUR2	284.98	159.92	116.78	80.92	90.79	88.50	90.03	94.96	92.56
Diff. %	30.33	10.87	8.56	15.35	8.45	6.87	9.44	9.22	10.07
Year	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
iBUR	78.41	63.95	50.39	92.03	96.97	83.47	140.46	139.99	155.73
BUR2	85.84	70.55	55.15	101.84	108.38	55.48	116.83	114.36	123.37
Diff. %	9.47	10.32	9.44	10.65	11.76	-33.5	-16.82	-18.30	-20.77

Year	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
iBUR	182.27	157.57	251.63	256.05	300.64	238.21	328.06
BUR2	176.51	160.31	222.85	289.13	302.13	264.31	339.28
Diff. %	-3.1	1.73	-11.43	12.91	1.49	10.95	3.42

4.1.6 Assessment of completeness

The current inventory covers greenhouse gas emissions from 4 categories: Mineral industry (2.A), Metal industry (2.C), Non-energy products from fuels and solvent use (3.D) and Product uses as substitutes for ozone depleting substances (2.F) from 1990 to 2020. Table 4-7 shows the overview of the completeness status of estimated gases of under various source categories within the sector.

Table: 4-7: Assessment of completeness of GHG emissions under the IPPU sector

IPCC Category	Source Category	Status of Gas	
		CO_2	HFC
2.A-Mineral industry	2.A.1 – Cement production	E	-
	2.A.2 – Lime production	E	-
	2.A.3 – Glass production	NA	-
	2.A.4 – Other Process Uses of Carbonates	NE	-
	2.A.5 – Other	NO	-
2.B-Chemical Industry	2.B.1 – Ammonia Production	NO	-
	2.B.2 – Nitric Acid Production	-	-
	2.B.3 – Adipic Acid Production	-	-
	2.B.4 – Caprolactam, Glyoxylic and Glyoxylic Acid Production	-	-
	2.B.5 – Carbide Production	NO	-
	2.B.6 – Titanium Dioxide Production	NO	-
	2.B.7 – Soda Ash Production	NO	NO
	2.B.8 – Petrochemical and Carbon Black Production		
	2.B.9 – Fluorochemical and Carbon black Production	-	
	2.B.10 – Other (Please specify)	NO	NO
2.C-Metal Industry	2.C.1 – Iron and Still production	E	-
	2.C.2 – Ferroalloys production	NE	-
	2.C.3 – Aluminum production	NO	-
	2.C.4 – Magnesium production	NO	-
	2.C.5 – Lead production	NO	-
	2.C.6 – Zinc production	NO	-
	2.C.7 – Other (Please specify)	NO	NO
2.D-Non-Energy Products from Fuels and Solvent Use	2.D.1 – Lubricant Use	E	-
	2.D.2 – Paraffin Wax Use	IE	-
	2.D.3 – Solvent Use	-	-
	2.D.4 – Other (asphalt production and use	NO	NO
2.E-Electronics Industry	2.E.1 – Integrated Circuit or Semiconductor	-	NO
	2.E.2 – TFT Flat Panel Display	-	-
	2.E.3 – Photovoltaics	-	-
	2.E.4 – Heat Transfer Fluid	-	-
	2.E.5 – Other (Please Specify)	NO	NO
2.F-Product Uses as Substitutes for Ozone Depleting Substances	2.F.1 – Refrigeration and Air Conditioning	-	E
	2.F.2 – Foam Blowing Agent	-	E
	2.F.3 – Fire Protection	-	E
	2.F.4 – Aerosols	-	E

	2.F.5 – Solvents	-	NO
	2.F.6 – Other (Please Specify)	NO	NO
2.G-Other Product Manufacture and Use	2.G.1 – Electrical Equipment	-	-
	2.G.2 – SF_6 and PFCs from Other Product Use	-	-
	2.G.3 – N_2O from Product Uses	-	-
	2.G.4 – Other (Please Specify)	NO	NO
2.H-Other	2.H.1 – Pulp and Paper Industry	NA	-
	2.H.2 – Food and Beverages Industry	NA	-
	2.H.3 – Other (Please specify)	NO	NO

Abbreviations: E-Estimated, source categories included in the inventory; NO-Not Occurring; NE-Not Estimated; NA-Not Applicable, IE – Included Elsewhere

4.1.7 Sector specific planned improvements

Some significant improvements in the IPPU sector in the short and medium term are required. The short term improvements are planned in the following areas: (i) additional activity data (AD) collection to improve the completeness; (ii) accuracy and disaggregation of the AD; (iii) AD collection system, processing, and analysis; (iv) capacity building and institutional arrangement. The medium term improvements cover the following activities; (i) identifying the proper way to sustain the data collection for the HFCs consumption to improve the inventory of HFCs and PFCs; (ii). Consideration of the available data in Mongolia and identify the barriers to using the tier 2 method.

4.2 Mineral industry (2.A.)

The mineral industry of Mongolia covered cement and lime production. Both Cement production (2.A.1) and Lime production (2.A.2) constitute key categories, which have a significant influence on the total inventory of the IPPU sector in terms of the absolute levels of emissions.

Table 4-8: GHG emissions from Mineral industry source category of IPPU sector, 1990-2020

Cement and Lime production, Gg CO_2e											
Year	*Cement*	*Lime*	*Total*	*Year*	*Cement*	*Lime*	*Total*	*Year*	*Cement*	*Lime*	*Total*
1990	194.83	77.25	272.08	2001	29.92	22.58	52.50	2011	188.2	33.98	222.18
1991	100.25	57.22	157.47	2002	65.24	31.65	96.89	2012	154.39	51.15	205.54
1992	58.57	50.85	109.42	2003	71.74	31.65	103.39	2013	114.39	42.53	156.91
1993	36.38	38.40	74.78	2004	27.36	22.50	49.86	2014	181.79	43.50	225.29
1994	37.92	49.80	87.72	2005	49.46	60.90	110.36	2015	181.26	39.23	220.49
1995	48.09	38.55	86.64	2006	62.23	45.30	107.63	2016	191.12	35.70	226.82
1996	46.85	41.03	87.88	2007	79.52	32.48	111.99	2017	298.44	42.15	340.59
1997	49.33	43.20	92.53	2008	119.03	39.68	158.71	2018	412.74	44.03	456.76
1998	48.18	41.85	90.03	2009	103.83	31.35	135.18	2019	485.32	57.98	543.29
1999	45.75	37.20	82.95	2010	142.55	37.65	180.20	2020	522.53	52.65	575.18
2000	40.53	27.75	68.28								

The share of mineral industry in the IPPU sector was relatively high (95%) in base year and over the inventory years it has been declined up to (50%) in 2020, due to share of the sector, Product uses as substitutes for ozone depleting substances has been increased to 49.75%. Cement and Lime production share the emissions of the Mineral industry respectively 91% and 9% in 2020.

4.2.1 Cement production (2.A.1)

4.2.1.1 Category description

Cement is manufactured from limestone through a closely controlled chemical combination of calcium, silicon, aluminium, iron and other ingredients. During the cement production process, calcium carbonate ($CaCO_3$) is heated in a cement kiln at high temperature about 1,450°C to form lime and CO_2 in a process known as calcination. As next, the lime is combined with silica-containing materials to produce clinker (an intermediate product), with the earlier by-product CO_2 being released to the atmosphere. The clinker is then allowed to cool, mixed with a small amount of gypsum and potentially other materials (e.g. slag), and used to make a Portland cement. Until 2013 two main cement plants were operating in Mongolia, namely "Darkhan" cement plant which was built in 1968 and "Cement and Lime" cement plant was built in 1983 in Khutul, Darkhan-Uul province. These two plants used a wet-processing technology for cement production until 2014. They have shifted the technology from wet to dry-processing since 2014. "Cement and Lime" plant`s capacity increased to one million tonnes of cement per year with the new processing technology. "Mon-Cement materials limited liability company (LLC) was established in 2006 but it officially started to produce cement since 2013. Later "MAK Eurocement" LLC was established in 2017 and using dry processing technology.

Table 4-9: Capacity of cement plants in Mongolia

Cement Plant	*Built year*	*Capacity tonnes cement/year*	*Technology*
"Darkhan" Cement Plant	1968	NA	Wet process until 2013 Dry process since 2014
"Cement and Lime" Plant	1983	1 million	Wet process until 2013 Dry process since 2014
Mon-Cement materials LLC	2006	1 million	Dry process
MAK Eurocement LLC	2017	1 million	Dry process

Source:GGGI, 2018

In 1990, emissions from cement production constituted a share of around 71.6% (194.83 Gg CO_2e) in the total GHG emissions from mineral industry, it covered 90.8% (522.53 Gg CO_2e) in 2020.

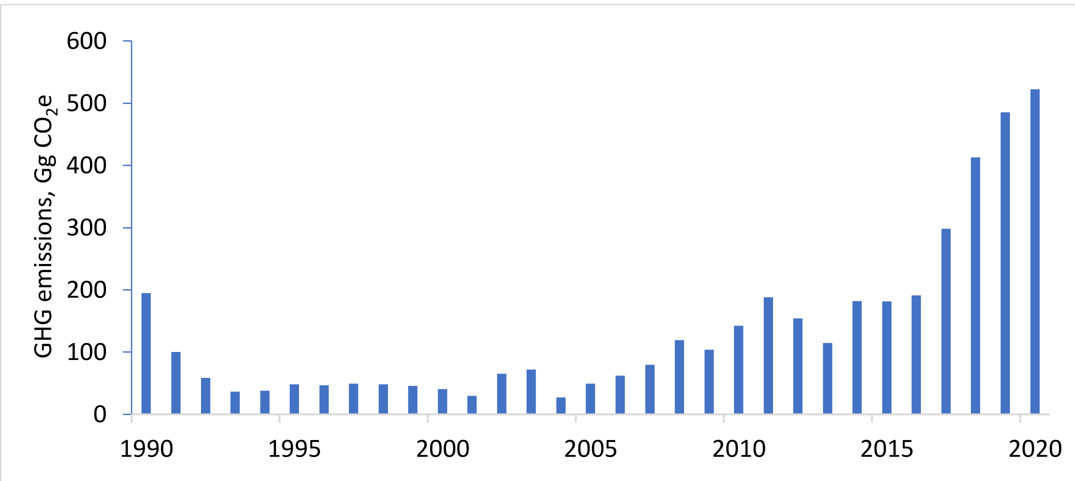

Figure 4-3: GHG emissions from Cement production in thousand tonnes

4.2.1.2 Methodological issues

4.2.1.2.1 Choice of method

The emissions from cement production are estimated by Tier 1 applying amount of cement produced and default emission factor in accordance with the decision tree of the 2006 IPCC GLs.

4.2.1.2.2 Activity data

Amount of cement production was taken from National Statistical office of Mongolia. Import and export of clinker are regarded as 0 due to lack of reliable data throughout the time series. Data from United Nations Commodity Trade Statistics Database (UN COMTRADE) implies that Mongolia is a net importing country for at least about a decade, however, they are omitted from estimation since they are significantly smaller than domestic production for most years and high in uncertainty. The default overall clinker fraction of 85% is applied based on an official letter from the Ministry of Food, Agriculture and Light Industry (MOFALI).

Table 4-10: Activity data of cement production

Mass of cement production within 1990-2020, thousand tonnes					
1990	440.8	2001	67.70	2011	425.8
1991	226.8	2002	147.60	2012	349.3
1992	132.5	2003	162.30	2013	258.8
1993	82.3	2004	61.90	2014	411.3
1994	85.8	2005	111.90	2015	410.1
1995	108.8	2006	140.80	2016	432.4
1996	106.0	2007	179.90	2017	675.2
1997	111.6	2008	269.30	2018	933.8
1998	109.0	2009	234.90	2019	1,098.0
1999	103.5	2010	322.50	2020	1,182.2
2000	91.7				

Source: NSO, 2021a

4.2.1.2.3 Emission factors and other parameters

The default emission factor of 0.52 tonnes CO_2/tonne clinker is applied.

Table 4-11: Emission factor for Clinker

Category	Emission factor	Source
Clinker	0.52 tonnes CO_2/tone clinker	2006 IPCC GLs, Vol.3, Part 1, Ch.2, Table 2.4

4.2.1.3 Category-specific recalculations

Tier 2 with the amount of clinker production was applied in iBUR, however, it became unavailable for recent years. In order to keep time-series consistency, recalculation is conducted applying Tier 1 throughout the inventory period.

4.2.1.4 Category-specific planned improvements

No improvements are planned.

4.2.2 Lime production (2.A.2)

4.2.2.1 Category description

Production of lime employs the process as described in cement production above. CO_2 is emitted as a result. Lime can be produced from the calcination of high calcium limestone ($CaCO_3$), or dolomite or dolomitic limestones that contain high magnesium as follows:

For high calcium limestones $CaCO_3\ (high\ purity\ limestone) + heat \rightarrow CaO\ (quicklime) + CO_e$

Limestone ($CaCO_3$) and dolomite ($CaCO_3.MgCO_3$) are basic raw materials commercially used in a number of industries including metallurgy (e.g. iron and steel) and glass manufacture. These are also used in construction and environmental pollution control. Lime produced therefore depends on the product requirements where it would be used.

The main lime industry of Mongolia is "Cement and Lime" plant. As mentioned above under the cement production session, the "Cement and Lime" plant was built in 1983 in Khutul, Darkhan-Uul province and its capacity of lime production is approximately 65.0 t/per year.

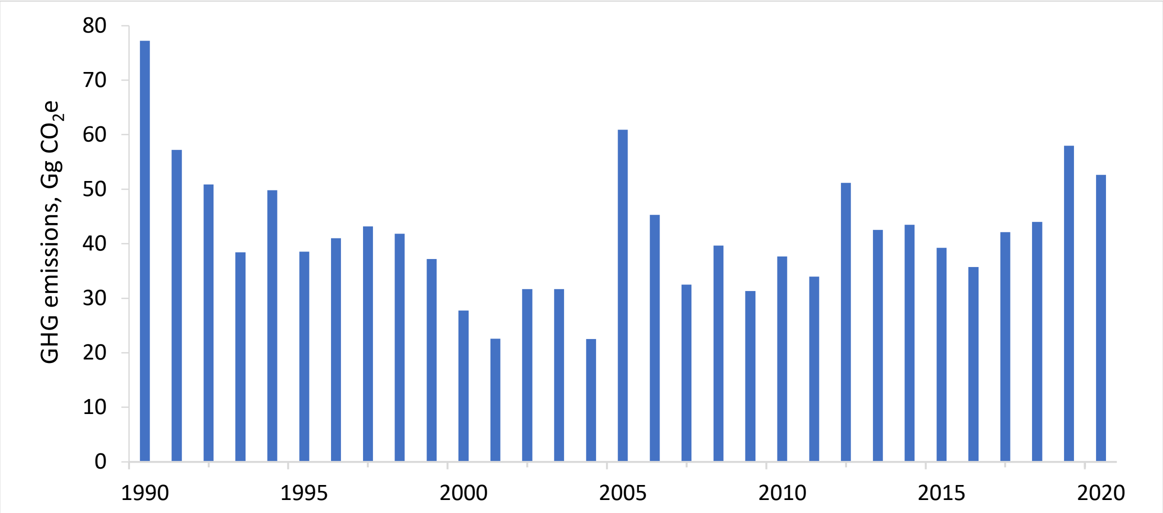

Figure 4-4: GHG emissions from lime production, 1990-2020, Gg CO_2

In 1990, lime production constituted a share of about 28.3% (77.25 Gg CO_2e), in 2020, it covered 9.15% (52.65 Gg CO_2e) in the total GHG emissions from Mineral industry source category.

4.2.2.2 Methodological issues

4.2.2.2.1 Choice of method

The emissions from lime production are estimated by Tier 1 applying amount of lime produced and default emission factor in accordance with the decision tree of the 2006 IPCC GLs.

4.2.2.2.2 Activity data

Amount of lime production from 1990-2020 was taken from the NSO.

Table 4-12: Activity data of cement production

Mass of lime production within 1990-2020, thousand tonnes					
1990	103.0	2001	30.1	2011	45.3
1991	76.3	2002	42.2	2012	68.2
1992	67.8	2003	42.2	2013	56.7
1993	51.2	2004	30.0	2014	58.0
1994	66.4	2005	81.2	2015	52.3
1995	51.4	2006	60.4	2016	47.6
1996	54.7	2007	43.3	2017	56.2
1997	57.6	2008	52.9	2018	58.7
1998	55.8	2009	41.8	2019	77.3
1999	49.6	2010	50.2	2020	70.2
2000	37.0				

Source: NSO, 2021a

4.2.2.2.3 Emission factors and other parameters

In the absence of country specific data, 85% production of high calcium lime and 15% production of dolomitic lime are assumed in accordance with the 2006 IPCC GLs. Therefore, a default emission factor of 0.75 tonnes CO_2/tonne lime produced is applied.

Table 4-13: Emission factor for lime production

Category	Emission factor	Source
High-calcium lime	0.75 tonnes CO_2/ tonne lime	2006 IPCC, Vol.3, Part 1, Ch.2, Table 2.4

4.2.2.3 Category-specific recalculations

There have been no recalculations of emissions from this category.

4.2.2.4 Category-specific planned improvements

No improvements are planned.

4.2.3 Glass production (2.A.3)

However, some glass industry companies in Mongolia own glass tempering furnaces, none of them have kilns for raw material production. Tempering doesn't contribute to IPPU emissions. Therefore, emission in this category is reported as not applicable (NA).

4.2.4 Other process uses of carbonates: Ceramics (2.A.4.a)

Red brick production under this category can emit CO_2 from carbonate in clay in a process similar to cement production. Production amount by piece is available from the statistical yearbook annually since 2000 and from 100 years statistics of Mongolia (1911-2011) every 5 year since 1940. Due to lack of information on average weight of a piece of brick, clay consumption amount per piece and/or consumed amount of clay as well as carbonate content of clay, estimation of this category is not realistic at moment. Other ceramic production at industrial level was not found at moment. There used to be ceramic tile production until 1995, however, record of production amount was not found. The category is reported as not estimated (NE) throughout time series.

4.2.5 Other process uses of carbonates: Other uses of soda ash (2.A.4.b)

A certain amount of soda ash import to Mongolia in recent years is reported in United Nations Commodity Trade Statistics Database (UN COMTRADE) international trade statistics at several hundred tonne/year. However, it is difficult to utilize the numbers as activity data at moment due to incomplete time series data and lack of information on usage. Therefore this category is reported as not estimated (NE).

4.2.6 Other process uses of carbonates: Non-metallurgical magnesia production (2.A.4.c)

There is no magnesium-related mine nor relevant production in Mongolia at moment. This category is reported as not occurred (NO).

4.3 Chemical industry (2.B.)

Currently none of relevant activities are found in Mongolia. Thus all subcategories are reported as not occurred (NO). In view of rich coal and petroleum resource in the national territory with a refinery under construction, petrochemical/coal chemical industry may be developed in a future.

4.4 Metal industry (2.C.)

This source category constitutes a small fraction around 0.11% as year of 2020 (Figure 4-1, Table 4-1 above) of the total IPPU share. The metal industry source category has covered the iron and steel production and have been estimated in Mongolia since 1995. Other metallurgical productions are not occurring in Mongolia. Table 4-14 shows time series GHG emissions from the metal industry.

Table 4-14: GHG emissions from Metal industry, 1990-2020

Year	*Emissions from Iron and Steel production, Gg CO_2*	*Year*	*Emissions from Iron and Steel production, Gg CO_2*	*Year*	*Emissions from Iron and Steel production, Gg CO_2*
1990-1994	NO	*2003*	3.14	*2012*	5.45
1995	1.25	*2004*	4.39	*2013*	4.48
1996	1.54	*2005*	5.24	*2014*	5.15
1997	1.82	*2006*	5.60	*2015*	3.50
1998	1.30	*2007*	6.43	*2016*	3.14
1999	1.05	*2008*	6.51	*2017*	1.68
2000	1.04	*2009*	4.01	*2018*	2.34
2001	0.80	*2010*	5.14	*2019*	2.29
2002	1.27	*2011*	4.80	*2020*	1.22

4.4.1 Iron and steel production (2.C.1)

4.4.1.1 Category description

Iron and steel production in Mongolia uses only Electric Arc Furnaces (EAF) technology. The inventory calculation under this source category, therefore, includes only pig iron production from metallurgical coke and steel production in EAF.

Modern steel production with EAFs has relatively long history in Darkhan-Uul province by Darkhan metallurgical plant starting from 1995. The majority of CO2 emissions from this category come from the utilization of metallurgical coke in the production of pig iron and from the consumption of other process by-products at the iron and steel mill.

4.4.1.2 Methodological issues

4.4.1.2.1 Choice of method

The emissions from steel production are estimated by Tier 1 applying an amount of steel produced and default emission factor for EAF in accordance with the decision tree of the 2006 IPCC GLs.

4.4.1.2.2 Activity data

Activity data on steel production (steel bloom) were obtained from the NSO of Mongolia.

Table 4-15: Activity data of Iron and Steel production

Mass of Iron and Steel production within 1990-2020, thousand tonnes					
1990-1994	NO	*2003*	39.3	*2012*	68.1
1995	15.6	*2004*	54.9	*2013*	56.0
1996	19.2	*2005*	65.5	*2014*	64.4
1997	22.7	*2006*	70	*2015*	43.7
1998	16.3	*2007*	80.4	*2016*	16.8
1999	13.1	*2008*	81.4	*2017*	21.0
2000	13.0	*2009*	50.1	*2018*	29.2
2001	10.0	*2010*	64.2	*2019*	28.6
2002	15.9	*2011*	60.0	*2020*	15.3

Source: NSO, 2021a

4.4.1.2.3 Emission factors and other parameters

In the absence of country specific data, a default emission factor of 0.08 tonnes CO_2/tonne steel produced is applied.

Table 4-16: Emission factor for Iron and Steel Production

Type of Steelmaking Method	Emission factor	Source
Electric Arc Furnace	0.08	IPCC 2006 GLs, Vol.3, Part 1, Ch.4, Table 4.1

4.4.1.3 Category-specific recalculations

There have been no recalculations of emissions from this category.

4.4.1.4 Category-specific planned improvements

Since this category is not identified as a key category, improvement is not prioritized.

4.4.2 Iron and steel production (2.C.1: other)

In October 2009, Khukh Gan joint-stock company in Erdenet City established a direct reduced iron (DRI) production facility with an annual production capacity of 30,000 t. CO_2 and CH_4 are emitted during DRI production including coke production.

Emission related to DRI production predominantly comes from oxidization of reducing gas (CH_4, CO) and other carbon sources originated from fossil fuels (natural gas, coking gas and/or coke). Thus, it is reported as IE (Included elsewhere) to 1.A.2 (Fuel combustion: Manufacturing and construction industries) until additional information to distinguish energy and non-energy emissions will be available. According to the the 2006 IPCC GLs, annual production is activity data for Tier 1 and non-energy fuel consumptions in Terajoule (TJ) by fuel type for Tier 2. Data availability, emission factors and double-counting issues will be further investigated.

Production data of cast iron after 2008 is available in Industrial Statistics 2017, with annual production generally less than 200 t. Cast iron is usually produced in electric induction furnace or electric arc furnace, however, the 2006 IPCC GLs doesn't provide estimation method for cast iron specifically. This subcategory is reported as not estimated (NE).

4.4.3 Ferroalloys production (2.C.2)

It is likely that there is FeSi50 production in Mongolia. This activity emits CO_2 and CH_4. However, it is impossible to estimate emissions at moment due to lack of information on annual production amount in Mongolia. This category is reported as NE.

If annual production data will be available, we would apply Tier 1 methodology with CO_2 and CH_4 emission factors deduced from Tables 4-5 and 4-7 of the 2006 IPCC GLs, respectively.

4.4.4 Aluminium production, magnesium production (2.C.3, 2.C.4)

Mongolia doesn't have production of these metals. These categories are reported as NO.

4.4.5 Lead production, zinc production (2.C.5, 2.C.6)

There are substantial lead and zinc ores production and export in Mongolia. Concentrate production is conducted or planned domestically, however, Mongolia doesn't have smelting facility of these metals at moment which leads to IPPU emissions. These categories are reported as NO.

4.5 Non-energy products from fuels and solvent use (2.D)

In this source category have been included only GHG emissions from lubricant use in industrial and transport applications. Mongolia is importing the lubricants due to there is no oil refineries until now. Lubricants can be used for a variety of purposes, namely motor oils and industrial oils, greases which differ in terms of physical characteristics, and commercial applications. It's complicated to determine which fraction of lubricant consumed in machinery and in vehicles is actually combusted and emitted CO_2 emissions. Therefore, it has been assumed that all amount of imported/ produced lubricants consumed as motor and industrial oils. This assumption is that all amount of lubricant imported/produced is consumed in the same year. There is no local lubricants manufacturing. The CO_2 emissions from this source category can be seen from Table 4-17 below.

Table 4-17: GHG emissions from non-energy products from fuels and solvent use source category of IPPU sector, Gg CO_2

Year	Emissions from Lubricant use, Gg CO_2	*Year*	Emissions from Lubricant use, Gg CO_2	*Year*	Emissions from Lubricant use, Gg CO_2
1990	12.89	*2001*	1.85	*2011*	3.07
1991	2.45	*2002*	3.68	*2012*	0.62
1992	7.36	*2003*	1.85	*2013*	0.62
1993	6.15	*2004*	1.23	*2014*	0.62
1994	3.07	*2005*	1.23	*2015*	0.62
1995	0.62	*2006*	1.23	*2016*	0.62
1996	0.62	*2007*	1.23	*2017*	0.31
1997	0.62	*2008*	1.85	*2018*	0.25
1998	1.23	*2009*	1.85	*2019*	0.06

1999	1.85	*2010*	1.85	*2020*	0.04
2000	1.23	-		-	

4.5.1 Lubricant use (2.D.1)

4.5.1.1 Category description

In this estimation, it is assumed that all the lost lubricant is converted to CO_2, in accordance with the 2006 IPCC GLs. In this estimation, it is assumed that all the lost lubricant is converted to CO_2, in accordance with the guidelines. This source category constitutes a minute fraction of around 04 % share of the IPPU sector in 2020. The amount of the lubricant consumption had being declined continuously year since 2011.

4.5.1.2 Methodological issues

4.5.1.2.1 Choice of method

The emissions from lubricant were estimated by Tier 1 applying consumption of lubricant and default parameters in accordance with the decision tree of the 2006 IPCC GLs.

4.5.1.2.2 Activity data

Lubricant consumption is reported in energy sector as a non energy purposes in the reference approach. Data was taken from the International Energy agency (IEA) in order to use same data source as energy sector.

Table 4-18: Activity data of Lubricant Use

Year	*Mass of Lubricant use, terajoules*	Year	*Mass of Lubricant use, terajoules*	Year	*Mass of Lubricant use, terajoules*
1990	879.0	*2001*	126.0	*2011*	209.0
1991	167.0	*2002*	251.0	*2012*	42.0
1992	502.0	*2003*	126.0	*2013*	42.0
1993	419.0	*2004*	84.0	*2014*	42.0
1994	209.0	*2005*	84.0	*2015*	42.0
1995	42.0	*2006*	84.0	*2016*	42.0
1996	42.0	*2007*	126.0	*2017*	21.0
1997	42.0	*2008*	126.0	*2018*	17.0
1998	84.0	*2009*	126.0	*2019*	4.0
1999	126.0	*2010*	126.0	*2020*	2.9
2000	84.0				

Source: International Energy Agency, https://www.iea.org/

4.5.1.2.3 Emission factors and other parameters

In the absence of country specific data, default Oxidation during use factor of 0.2 and carbon content of 20 tonne-Carbon (C)/Terajoules (TJ) are applied.

Table 4-19: Emission factor for Lubricant use

Carbon content of lubricant type (tonne-C/TJ)	Emission factor	Source
20	0.2	IPCC 2006 GLs, Vol.3, Part 1, Ch.5, Table 5.2

4.5.1.3 Category-specific recalculations

There have been no recalculations of emissions from this category.

4.5.1.4 Category-specific planned improvements

This source category is responsible for a minor fraction of the IPPU related emissions (Figure 4-1 above) and is therefore not considered a key category. Since this category is not identified as a key category, improvement is not prioritized.

4.5.2 Paraffin wax use (2.D.2)

Paraffin wax and bituminous fuel are mixed in statistics, and it is difficult to separate activity data. It can be regarded that this category is Included elsewhere (IE) in energy sector. Improvement in energy statistics ("non-energy use") would enable estimation of this category.

4.5.3 Solvent use (2.D.3)

Only NMVOC (Non-methane volatile organic compounds) emission is to be reported under this category and the 2006 IPCC GLs doesn't provide methodology. However, solvent is used in Mongolia, it doesn't contribute to IPPU GHG emissions. GHG emissions are reported as not applicable (NA).

4.5.4 Non-energy products from fuels and solvent use: other (2.D.4)

This category includes asphalt production and use. However, the first asphalt production plant was established in 2019, the production is quite limited at moment. According to the 2006 IPCC GLs no direct GHG emissions will be accounted under this category but precursors (NMVOC, CO, SO_2). GHG emissions are reported as not applicable (NA).

4.6 Electronics industry (2.E.)

Currently none of relevant activities are found in Mongolia. All subcategories are thus reported as not occurred (NO).

4.7 Product uses as substitutes for ozone depleting substances (2.F)

All the Substitutes for Ozone Depleting Substances (ODS) are imported, there is no local production of these chemicals. It is also assumed that there are no exports from Mongolia for these ODS and no chemicals are recovered or destroyed at the equipment end-of-life. Therefore, consumption is fully depends on the import of the country. The consumption of ODS alternatives chiefly HFCs in commercial refrigeration and mobile air-conditioning sector in Mongolia has grown rapidly over the past decade due to robust development of the construction industry and the commercial and servicing sectors. Unless some action will be taken, the total consumption of HFCs is projected to increase from 39.86 t in 2015 to 413 t within 2030, at growth rates of 10% to 110% per year depending on the substance (NOA, 2021) Hydrofluorocarbons (HFCs) are serving as alternatives ODS being phased out under the Montreal Protocol.

Current and expected application areas of HFCs include:

- refrigeration and air conditioning;

- fire suppression and explosion protection;
- aerosols;
- solvent cleaning;
- foam blowing agents;
- other applications.

In Mongolia the emissions from this source category include HFCs emissions from following application areas:

- Refrigeration (stationary, mobile) and Air Conditioning (stationary, mobile) (2.F.1);
- Fire Protection (2.F.3);
- Foam Blowing Agents (2.F.2);
- Aerosols (2.F.4);

The emissions from the fluorinated substitutes for ODS were estimated from following HFCs such as HFC-23, HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-245fa and HFC-227ea in Mongolia. The consumption of HFCs in Mongolia was taken from *"Ozone Depleting Substances Alternative Survey Report"*, 2016 and *"Ozone Depleting Substances Alternative Survey and HFCs Inventory Report 2016-2020*" prepared by NOA. Table 4-20 provides the main applications areas for HFCs which have been counted in Mongolia.

Table 4-20: Main application areas for HFCs in Mongolia

Application areas		Chemicals							
		HFC-23	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	HFC-245fa	HFC-227ea
Refrigeration	Domestic				x				
	Commercial	x		x	x	x			
	Large systems			x	x	x			
	Transport				x				
	Industrial chiller	x			x				
Air Conditioning	Residential and commercial		x	x	x				
	Chillers			x	x				
	Mobile				x				
Aerosols	Medical				x				
Foam Blowing Agents	Extruded Polystyrene						x	x	
Fire Protection				x					x

Note:x=existing substances
Sources: NOA, 2016; NOA, 2021

The following table provides the 100-year time horizon GWP of HFCs, which are most commonly used in products imported in Mongolia relative to CO_2. This table is adapted from IPCC the Second Assessment Report (SAR), 1995.

Table 4-21: Global warming potentials (GWPs) for HFCs

Common name	*GWP values for 100-year time horizon*	*Source*
HFC-32	650	Second assessment report (SAR), 1995
HFC-125	2,800	
HFC-134a	1,300	
HFC-227ea	2,900	
HFC-143a	3,800	
HFC-152a	140	

Abbreviations: NA-Not applicable

GHG emissions from product uses as substitutes, the activity data were available only from 2012, so the emissions estimation from HFCs, then it back-calculates to the introduction year. The year of introduction for HFC 134a (Mobile Air Conditioning) was 2007, HFC-32, HFC-125, HFC-134a, HFC-143a (Refrigeration and Stationary Air Conditioning), HFC 152a (Foam Blowing Agents), and HFC-125 (Fire Protection) was 2010, HFC 134a (Aerosols) was 2012, HFC 227ae (Fire protection) was 2017, HFC 245fa (Foam Blowing Agents) was 2018 respectively (NOA, 2021).

Table 4-22: GHG emissions from product uses as substitutes for ozone depleting substances (HFCs), 2007-2020, Gg CO_2e

Year	*Refrigeration and Air Conditioning*	*Foam Blowing Agents*	*Fire Production*	*Aerosols*	*Total*
	Gg CO_2e				
1990-2006	NO	NO	NO	NO	NO
2007	3.10	NO	NO	NO	3.10
2008	9.45	NO	NO	NO	9.45
2009	19.27	NO	NO	NO	19.27
2010	35.56	0.08	0.03	NO	35.67
2011	58.81	0.19	0.08	NO	59.09
2012	89.73	0.33	0.16	0.30	90.52
2013	100.89	0.49	0.27	0.65	102.30
2014	107.24	0.61	0.37	NO	108.22
2015	100.79	0.74	0.44	NO	101.97
2016	192.80	0.87	0.50	NO	194.18
2017	286.47	0.94	0.68	NO	288.09
2018	380.72	0.99	0.81	NO	382.53
2019	471.23	1.03	0.91	NO	473.17
2020	569.28	1.05	0.97	NO	571.30

The GHG emissions from Product uses as substitutes for ozone depleting substance are continuously growing in Mongolia and it accounts for around 49.78 % of the total greenhouse gas emissions from the IPPU sector and which estimated as the second largest GHG inventory emitter source of the IPPU sector in 2020.

Between 2007 and 2020, the GHG emissions from Product uses as substitutes for ozone depleting substances increased from 3.10 Gg CO_2e to 571.30 Gg CO_2e. The result shows the emissions from the category jumped continuously and sharply.

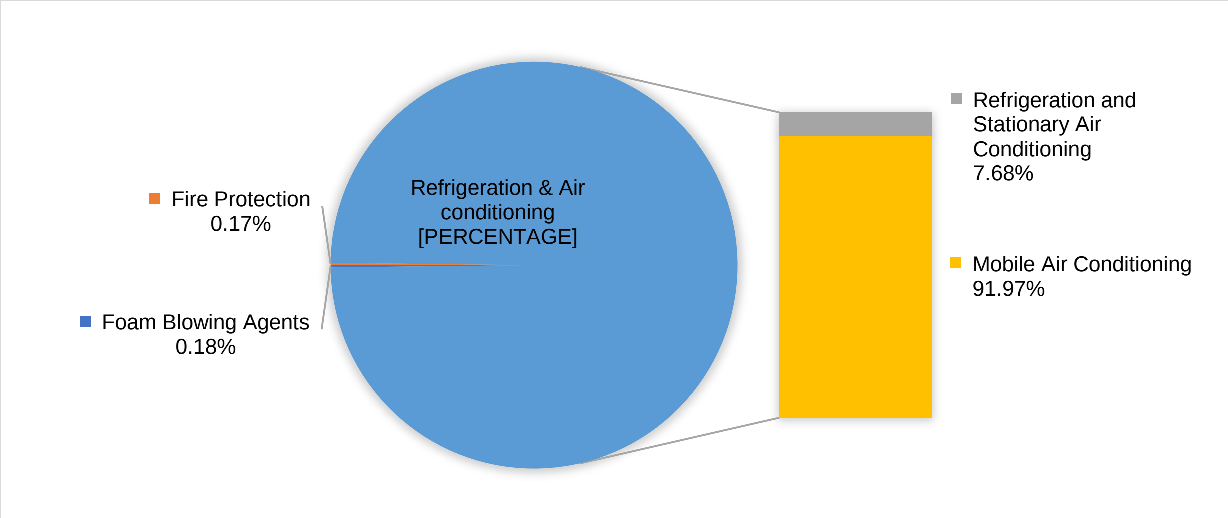

Figure 4-5: Share of each subcategories in total GHG emissions from Product uses as substitutes for ozone depleting substances (HFCs), 2020

Figure 4-5 shows that Refrigeration and air conditioning (RAC) is the dominant source of HFCs emissions, the majority HFCs consumption in Mongolia takes place in the RAC sector constituting 99.65% from product uses as substitutes for ozone depleting substances and 91.97% of the total GHG emissions of the RAC originated from mobile air conditioning in 2020. The rest of the subsectors contribute a minor amount to the total emissions from the product uses as substitutes for ozone depleting substances sector.

4.7.1 Refrigeration and air conditioning (2.F.1)

4.7.1.1 Category description

Refrigerants are imported as bulk gas or pre-charged in equipment. Bulk gas is consumed at servicing and installation in some cases. As a country with a cold climate, cooling demand is not very large but GHG emissions from mobile air conditioning consumption is relatively higher with 91.97% of Product uses as substitutes for ozone depleting substances sector in 2020. The dominant bank of HFCs in Mongolia is HFC-134a in mobile air conditioning.

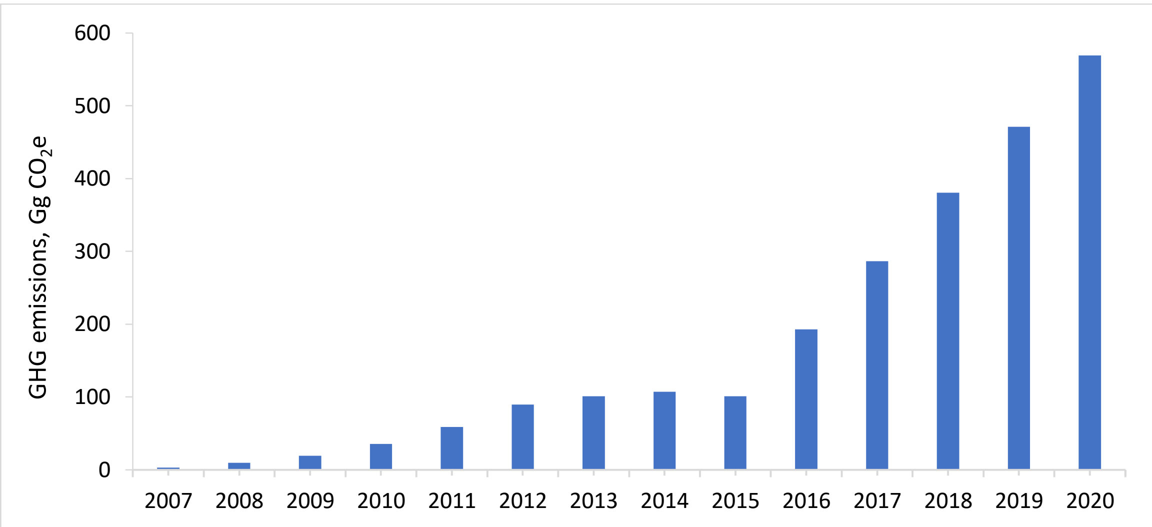

Figure 4-6: GHG emission trend of Refrigeration and air conditioning, 2007-2020

4.7.1.2 Methodological issues

4.7.1.2.1 Choice of method

Tier 1 a/b method was selected for emissions estimation from RAC because of a lack of detailed data. Consumption amounts can be applied as activity data.

The Tier 1 method used the default emission factors and aggregated activity data values of consumption of substitute for Ozone Depleting Substances (ODS) carried out at the application level rather than for individual products or equipment types.The method then back-calculates the development of banks of a refrigerant from the current reporting year to the year of its introduction (IPCC, 2006).

4.7.1.2.2 Activity data

Consumption data of HFCs in imported equipment, for the period 2012-2015 were obtained from the "Ozone Depleting Substances Alternative Survey Report" prepared through a project implemented by the National Ozone Authority (NOA) of the MET in cooperation with the United Nations Environmental Program (UNEP) and Climate and Clean Air Coalition (CCAC). The data covering the years 2016-2020 were taken from the "Ozone Depleting Substances Alternative Survey and HFC Inventory Report 2016-2020" prepared by NOA, through a project named "Capacity Development to Establish a National GHG Inventory Cycle of Continuous Improvement" implemented by Ministry of Environment of Mongolia and Japan International Cooperation Agency (JICA). According to the reports, Refrigeration and Stationary Air Conditioning importing data were collected from the Customs General Administration (CGA) of Mongolia, and Mobile Air Conditioning importing data was collected from the NSO (NOA, 2021).

Table 4-23: Activity data by HFC gas types

Year	*Refrigeration and Stationary air conditioning*				*Mobile air conditioning*	*Foam blowing agents*	*Fire protection*	*Aerosols*
	HFC-32	*HFC-125*	*HFC-134a*	*HFC-143a*	*HFC-134a*	*HFC-152a*	*HFC-125*	*HFC-134a*
2012	4.89	10.85	5.40	6.48	153.63			0.46
2013	9.10	4.02	9.28	2.41	96.72	3.125	1.05	0.537
2014	29.66	5.22	30.49	1.24	49.99			
2015	2.19	2.67	3.26	0.34	38.32			
2016	1.60	4.09	1.89	2.44	530.76	3.500		
2017	1.96	9.49	2.87	4.45	591.35			
2018	5.05	19.36	6.05	5.33	637.86			
2019	6.81	10.46	7.52	3.61	712.99			

Sources: NOA, 2016; NOA, 2021

4.7.1.2.3 Emission factors and other parameters

The default emission factor of each HFC gas in Refrigeration and air conditioning is 15% per year and the average equipment lifetime is 15 years of Tier 1 a/b 2006 GL were applied. Destruction at the end-of-life is 0% as it is not implemented in Mongolia. Imported refrigerants as bulk is added to the previous estimation in iBUR. Allocation to subcategory level was improved which slightly increased consumption and emissions.

Table 4-24: Emission factors and other parameters by gas species in refrigeration and air conditioning

Gas species	Lifetime (year)	Emission Factor (%)	Growth Rate (%)	Source
HFC-32	15	15	3.02	2006 IPCC GLs, Vol.3, Part 2, Ch.7, Table 7.8
HFC-125	15	15	4.67	
HFC-134a	15	15	10.03	
HFC-143a	15	15	20	

4.7.1.3 Category-specific recalculations

Assumptions for activity data were reviewed and updated.

4.7.1.4 Category-specific planned improvements

The Government of Mongolia ratified Kigali Amendment under the Montreal Protocol on January 18, 2022. Overall goal of the Amendment is to phase down hydrofluorocarbons (HFCs) consumption (https://legalinfo.mn/). Once ratified it, Mongolia will need to freeze the consumption of HFCs at its baseline level starting from 2024 and phase down HFCs consumption to 80% by year 2047 and mandates to report annual consumption of bulk HFCs. It can facilitate data collection in comparison to ad-hoc surveys as has been done (NOA, 2021).

4.7.2 Foam blowing agents (2.F.2)

4.7.2.1 Category description

HFC-152a has been occasionally imported in Mongolia for Extrude Polystyrene (XPS) production since 2013 (NOA, 2016). More recently since 2018, HFC-245fa has been imported for Polyurethane Spray (NOA, 2021). However, some of them might be stored for a few years, so it is not possible to obtain the exact year of consumption. Thus, it is assumed that all imported HFCs are consumed within the imported year. GHG emissions from foam blowing agents contributed 0.18% to the total emissions from the Product uses as substitutes for ozone depleting substances sector in 2020. Figure 4-7 shows between 2010 and 2020, the GHG emissions of foam blowing agent increased from 0.08 Gg CO_2e to 1.05 Gg CO_2e.

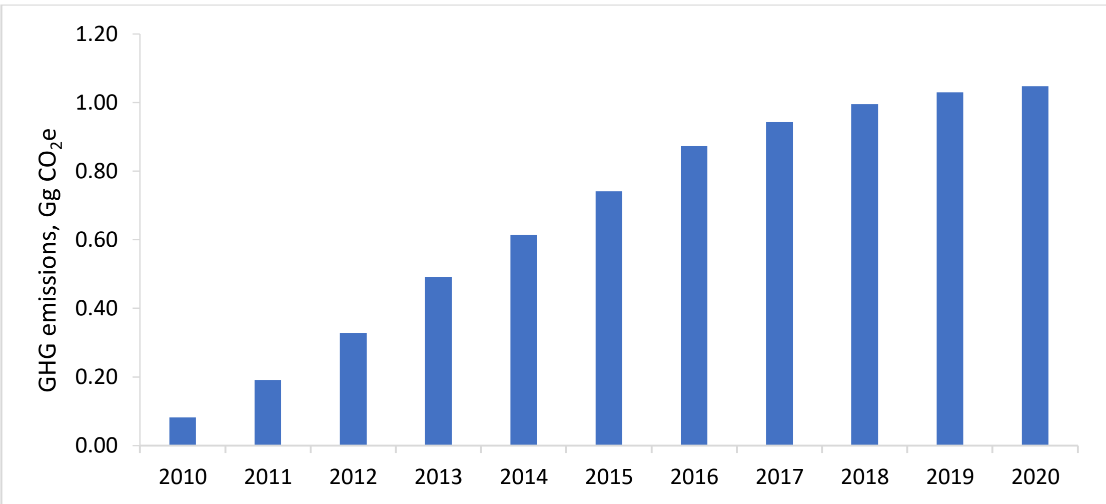

Figure 4-7: GHG emission trend of Foam blowing agent, 2010-2020

4.7.2.2 Methodological issues

4.7.2.2.1 Choice of method

Tier 1a of the 2006 IPCC GLs is selected for estimation from Fire protection.

4.7.2.2.2 Activity data

The HFC consumption data in foam-blowing agents were acquired from the same reports, which are reflected in 4.7.1.2.2. According to the reports, foam importing data from the CGA and NOA (NOA, 2021).

4.7.2.2.3 Emission factors and other parameters

According to the 2006 IPCC GLs, the default emission factors were applied. The default emission factor of HFC-152a is 50% in first year, 25% in subsequent year and HFC-245fa is 15% in first year, 1.5% in subsequent year in Foam blowing agents (IPCC, 2006).

No destruction at the end of life is assumed because there is no municipal waste incinerator in Mongolia.

Table 4-25: Emission factors by gas species in foam blowing agents

Gas species	*Use (cell type)*	*EF in first year (%)*	*EF in Subsequent years (%)*	*Source*
HFC-152a	Extrude Polystyrene (closed cell)	50	25	2006 IPCC GLs, Vol.3, Part 1, Ch.7, Table 7.7
HFC-245fa	Polyurethane Spray (closed cell)	15	1.5	

4.7.2.3 Category-specific recalculations

Assumptions for activity data were reviewed and updated.

4.7.2.4 Category-specific planned improvement

Since this category is not identified as a key category, improvement is not prioritized. If a waste incinerator will be installed in Mongolia, destruction at the end-of-life maybe considered.

4.7.3 Fire protection (2.F.3)

4.7.3.1 Category description

Fire protection equipments using HFCs have been rarely imported. Equipments using HFC-125 were imported in 2013 (NOA, 2016) and HFC-227ea in 2017 (NOA, 2021) respectively. Import in other years are considered as zero. Emissions from fire protection equipment shared with 0.17% in total GHG emissions from Product uses as substitutes for ozone depleting substances sector in 2020. Between 2010 and 2020 GHG emissions from fire protection increased continuously from 0.03 Gg CO_2e to 0.97 Gg CO_2e.

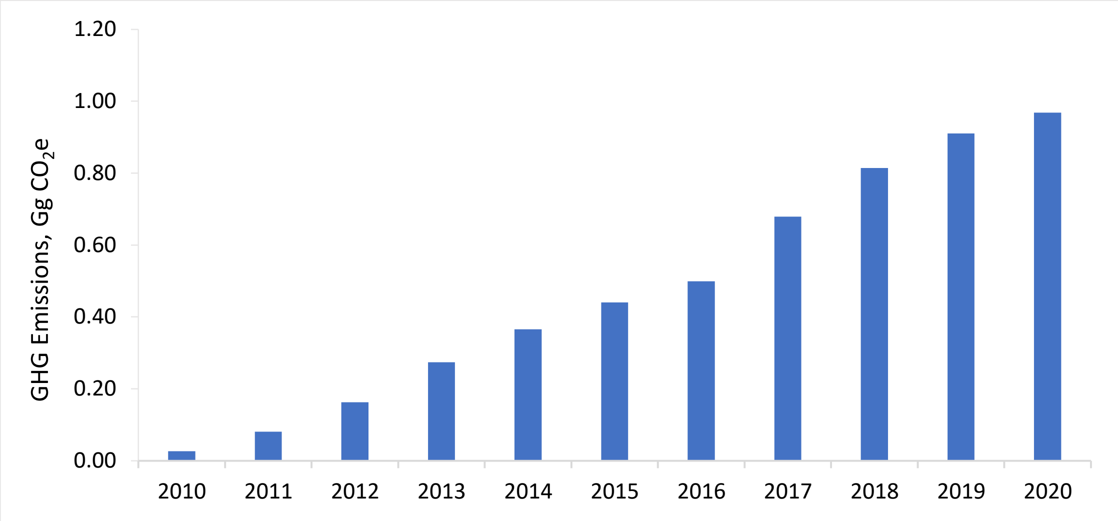

Figure 4-8: GHG emission trend of Fire protection, 2010-2020

4.7.3.2 Methodological issues

4.7.3.2.1 Choice of method

Tier 1a of the 2006 IPCC GLs is selected for estimation from Fire protection.

4.7.3.2.2 Activity data

The consumption data of HFCs in imported fire protection equipment were acquired from the same reports, which are reflected in 4.7.1.2.2. According to the reports, consumption data was collected from the CGA (NOA, 2021).

4.7.3.2.3 Emission factor and other parameters

According to the 2006 IPCC GLs, default emission factors were applied. No destruction at the end of life is assumed.

Table 4-26: Emission factors and other parameters of gas species in fire protection product

Gas species	*Growth rate (%)*	*Life time (y)*	*Emission factor (%)*	*Source*
HFC-125	3	15	4	2006 IPCC GLs,
HFC-227ea	3	15	4	Vol.3, Part 1, Ch.7

4.7.3.3 Category-specific recalculations

The emission factor was reviewed and updated.

4.7.3.4 Category-specific planned improvements

Since this category is not identified as a key category, improvement is not prioritized.

4.7.4 Aerosols (2.F.4)

4.7.4.1 Category description

Some Metered Dose Inhalers (MDIs) contain HFC-134a were imported in Mongolia in 2012 and 2013. They are substituted to non-HFCs products in recent years (NOA, 2016) .

4.7.4.2 Methodological issues

4.7.4.2.1 Choice of method

Tier 1a of the 2006 IPCC GLs was selected.

4.7.4.2.2 Activity Data

The consumption data of aerosols were obtained from the same sources, which are reflected in 4.7.1.2.2. According to the reports, NOA collected aerosol data from the Medicine and Medical Appliance Control and Regulatory Agency (MMACRA) (NOA,2021).

4.7.4.2.3 Emission factors and other parameters

According to the 2006 IPCC GLs, default emission factor of 50% was applied.

4.7.4.3 Category-specific recalculations

There have been no recalculations of emissions from this category.

4.7.4.4 Category-specific planned improvements

Since this category is not identified as a key category, improvement is not prioritized.

4.7.5 Solvents (2.F.5)

4.7.5.1 Category description

Currently none of relevant activities are found in Mongolia. All subcategories are thus reported as NO.

4.7.6 Other Applications (2.F.6)

4.7.6.1 Category description

Currently, none of relevant activities are found in Mongolia. All subcategories are thus reported as NO.

4.8 Other Product Manufacture and Use (2.G)

4.8.1 Electrical Equipment (2.G.1)

SF_6 gas insulators are installed in the 4th Fire Power Plant which is the main power plant for the capital city of Ulaanbaatar. They are "Sealed-for-life equipment" and there would be no leakage except for accidents. Installed capacity is not known. Application of such equipment in other places is not studied yet. Use (2.G.1.b) of such equipment is reported as NA and disposal (2.G.1.c) as NE for the time being. Production (2.G.1.a) is reported as NO.

4.8.2 SF_6 and PFCs from Other Product Uses: Other (2.G.2.c)

A certain amount of fluorides (HS code: 282619 "Fluorides of metals except ammonium, sodium, aluminium" which may include SF_6, and HS code: 382478 "Mixtures containing PFCs or HFCs" which may include PFCs) import/export to Mongolia in recent years is reported in UN COMTRADE international trade statistics. However, exact amount of each gas species and their uses are not clear. Therefore we report as NE. This category may be reallocated to other category(s) when uses will be clarified in a future.

4.8.3 N_2O from Product Uses (2.G.3)

N_2O used to be applied as anaesthetics for human previously in Mongolia, however, it is not used any more. There is no clear record when this transition happened. Based on expert judgement, we report emissions from Medical Applications (2.G.3.a) as NO after 2010 and NE before 2009. It is difficult to obtain historical consumption data. Propellant for Pressure and Aerosol Products (2.G.3.b) is reported as NE due to insufficient information at moment.

4.9 Other (2.H)

This category includes Paper and Pulp (2.H.1), Alcoholic Beverages and Bread And Other Food Production (2.H.2) industries. The Revised 1996 IPCC GLs provides methodology for NMVOCs emission estimation for this category which is not a direct GHG. These activities exist in Mongolia, however, don't contribute to IPPU GHG emissions. GHG emissions are reported as NA.

CHAPTER 5: AGRICULTURE

5.1 Overview of sector

The GHG inventory for the agriculture sector is conducted for three categories: enteric fermentation, manure management, and aggregate sources and non-CO_2 emissions on land. The GHG emissions from these three categories were directly dependent on the livestock population of the country. There are four discrete source categories of Mongolian agriculture sector such as: (i) the traditional semi-nomadic pastoral system, where camels, horses, cattle, sheep and goats are grazed together; (ii) mechanized large-area crop production of cereals and fodder crops; (iii) intensive farming, producing potatoes and other vegetables, with both mechanized and simple production methods; and (iv) intensive livestock, with housed dairy cattle, pigs and poultry.

The agriculture sector is the main contributor to overall national GHG emissions (excluding LULUCF) with its share of 51.97% (22,390.57 Gg CO_2e) in 2020 (Figure 5-1).

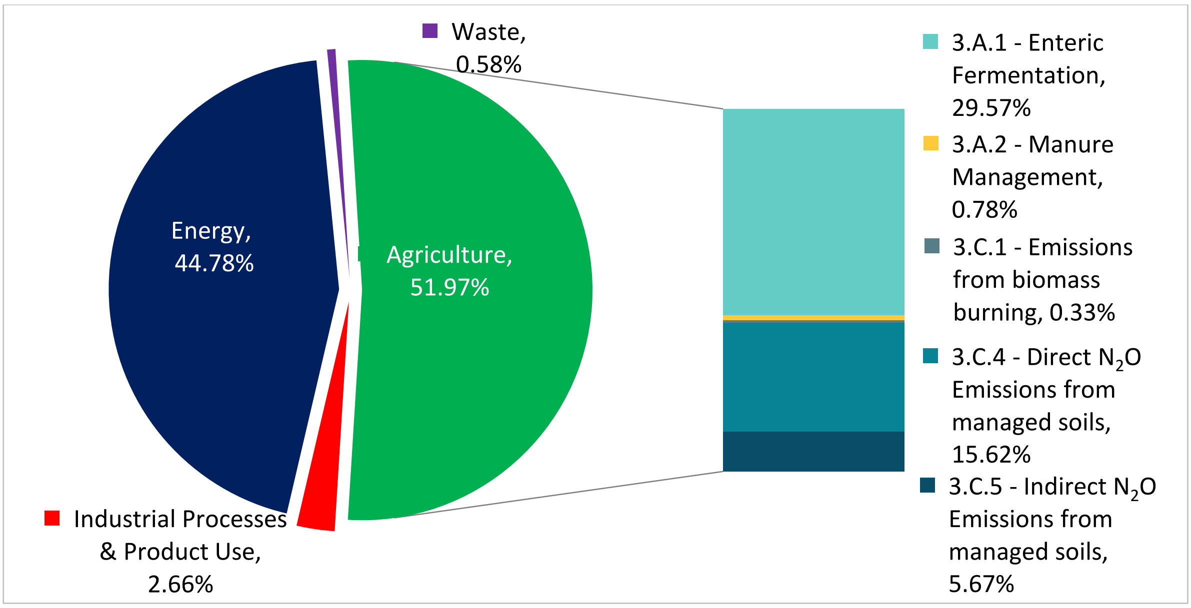

Figure 5-1: Share of each subsector of agriculture sector in total national GHG emissions (excl. LULUCF) in 2020

Between 1990 and 2020, the total GHG emissions originated from the agriculture sector tended to higher values, from 11,221.64 to 22,390.57 Gg CO_2e, increasing by 99.53%, (Table 5-1), in particular, due to increasing the number of domestic livestock which increased 25,856.90 thous.heads to 67,068.49 thous.heads, respectively. However animal number was fluctuated within the inventory period due to the dzud occurrence as explained below (Figure 5-2).

Table 5-1: Emissions from agriculture sector in 1990 and 2020

Source categories	*GHG*	*Emissions, Gg CO_2e* 1990	2020	*Change from 1990 (Gg CO_2e)*	*Change from 1990 (%)*
3.A.1 - Enteric fermentation	CH_4	6,310.67	12,741.16	6,430.49	101.90
3.A.2 - Manure management	CH_4	175.23	334.00	158.77	90.60
3.C - Aggregate sources and non-CO_2 emissions sources on land	CH_4, N_2O	4,735.74	9,315.42	4,579.67	96.70
3. Agriculture Total	CH_4, N_2O	11,221.64	22,390.57	11,168.83	99.53

Within the agriculture sector, enteric fermentation contributes the highest to the GHG emissions with 56.90% followed by aggregate sources and non-CO_2 emissions sources on land with 41.60% and manure management with 1.49% (Table 5-2).

Table 5-2: GHG emissions from agriculture by source categories, Gg CO_2e

Source categories	*Unit*	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*
3.A.1 - Enteric fermentation	Gg CO_2e	6,310.67	6,965.65	6,910.68	5,697.09	6,112.71	10,429.36	12,741.16
	%	56.24	59.85	57.91	51.90	56.67	52.71	56.90
3.A.2 -Manure management	Gg CO_2e	175.23	189.64	188.12	153.18	160.44	273.02	334.00
	%	1.56	1.63	1.58	1.40	1.49	1.38	1.49
3.C – Aggregate sources and non-CO_2 emissions sources on land	Gg CO_2e	4,735.74	4,482.79	4,834.27	5,127.24	4,512.90	9,085.48	9,315.42
	%	42.20	38.52	40.51	46.71	41.84	45.91	41.60
3. Agriculture Total	Gg CO_2e	11,221.64	11,638.09	11,933.07	10,977.51	10,786.05	19,787.87	22,390.57
	%	100	100	100	100	100	100	100

As seen from Figure 5-2, the aggregated emissions in the agricultural sector tend to fluctuate depending on the occurrence of drought and dzud, as well as forest and grasslands fires in certain years. Main driver of the fluctuations for emissions from agriculture sector is due to loss of livestock population during the natural disaster for the inventory period. There is a natural disaster named zud/dzud in which large numbers of livestock die due to severe, cold winter occasionally. In 1999-2000, 2000-2001 and 2001-2002, Mongolia was hit by three dzuds in a row, in which 3,341.4 thous.heads (10%), 4,152.2 thous.heads (14%), 2,177.6 thous.heads (8%) animals were lost, respectively. The fourth harsh winter was happened in 2009-2010 (within GHG inventory period of 1990-2020) and during this dzud over 11 million livestock was lost and it caused a 26% decreas from previous year's total. As result, methane and nitrous oxide emissions from domestic livestock were fluctuated following those long and short term impacts.

Compared to 2019, in 2020 GHG emissions demonstrated a decrease in all source categories of the agriculture sector. The decrease of emissions in 2020 depends on the following reasons: (i) last two years of this inventory, 60 percent of the total land area of the country has been affected by drought (ii) large number of livestock were preemptively slaughtered to prevent dzud risk, (iii) loss of 2.1 million head of livestock due to dzud.

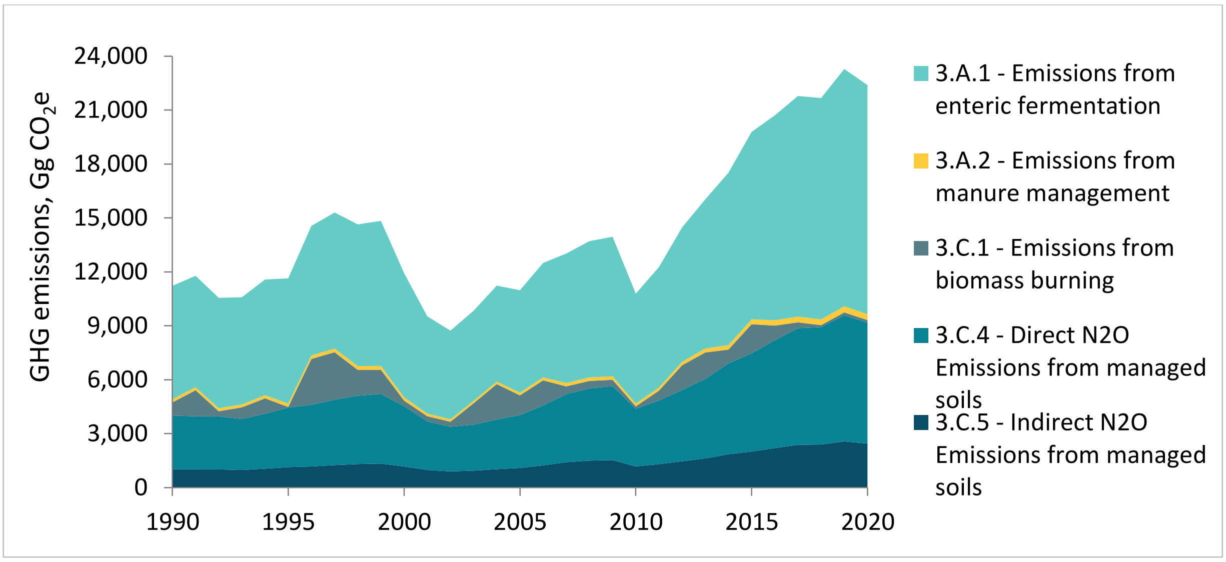

Figure 5-2: Trend in aggregated emissions by subcategories within agriculture sector for the period 1990-2020, Gg CO_2e

5.1.1 Methodological issues

In the Agriculture sector of Mongolia, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC GLs) have been used. Generally, emissions from Livestock (3.A) and Aggregate sources and non-CO_2 emissions sources on land (3.C) were estimated using the Tier 1 methodological approach and default EFs values. Country specific activity data for all the categories were used where it was available. Data from international data source (FAOSTAT) were used where country specific activity data was non-existent.

A summary description of methods used to estimate emissions by categories is provided in Table 5-3, while a more detailed descriptionis available in chapters 5.2-5.3 of the NIR.

Table 5-3: Summary of methods used to estimate GHG emissions for the agriculture sector

IPCC code	*Source categories*	*CH_4*		*N_2O*	
		Method	*EF*	*Method*	*EF*
3.A	*Livestock*	T1	D		
3.A.1	*Enteric fermentation*	T1	D	-	-
3.A.2	*Manure management*	T1	D	-	-
3.C	*Aggregate sources and non-CO_2 emissions sources on land*	T1/T2	CS/D	T1/T2	CS/D
3.C.1	*Emissions from biomass burning*	T1/T2	CS/D	T1/T2	CS/D
3.C.4	*Direct N_2O emissions from managed soils*	-	-	T1	D
3.C.5	*Indirect N_2O emissions from managed soils*	-	-	T1	D

Abbreviations: T1-Tier 1 method; T2-Tier 2 method; CS-Country Specific; EF-Emission Factors

5.1.2 Key categories

The key category analysis has been performed according to the provisions in Chapter 4 in Volume 1 of the 2006 IPCC GLs using the Approach 1. Separate key category analysis were conducted for total GHG emissions with exclusion and inclusion of the LULUCF sector, and also both for level and trend criterias. The key categories (excluding LULUCF) in 2020 assessed by level and trend criteria are presented in Table 5-4. Emissions from Enteric fermentation, Direct and Indirect N_2O emissions from managed soils categories were included in both level and trend assessment, and CH_4 emissions from manure management, CH_4 and N_2O emissions from biomass burning categories were included in trend assessment as key sources. More detailed information provided in Annex II.

Table 5-4: Key category analysis under the agriculture sector

IPCC code	*Source categories*	*GHG*	*Key Categories*
3.A.1	*Enteric fermentation*	CH_4	Yes (L,T)
3.A.2	*Manure management*	CH_4	Yes (T)
3.C.1	*Emissions from biomass burning*	CH_4	Yes (T)
3.C.1	*Emissions from biomass burning*	N_2O	Yes (T)
3.C.4	*Direct N_2O emissions from managed soils*	N_2O	Yes (L,T)
3.C.5	*Indirect N_2O emissions from managed soils*	N_2O	Yes (L,T)

5.1.3 Quality assurance and Quality control (QA/QC)

All applied information and data have been double-checked as much as possible. For instance, the activity data (AD) of livestock numbers from the statistical yearbooks of agriculture was cross-checked against information from the National Statistic Office (NSO) website. GHG emissions were estimated using AD and default factors and parameters from official sources and references. The experts from different sectors cross-checked the activity data and emission factors and/or other parameters used for other sectors. AD were checked for transcription errors between input data and calculation sheets. Calculations were examined focusing on units/scale and formulas. All AD, EFs, assumptions and methods used to estimate GHG emissions under this sector were documented and archived both in hard and electronic copies.

5.1.4 Uncertainties assessment and time series consistency

The uncertainty estimation of the 2020 inventory has been done according to the Tier 1 method presented in the 2006 IPCC GLs. Tier 1 method combines the uncertainty in activity data and emission factors, for each source category and GHG types, and then aggregates the combined uncertainties for all source categories and greenhouse gases to obtain the total uncertainty for the inventory.

Uncertainties related to the estimation of methane emissions from livestock, in particular, depend on the accuracy of the livestock characteristics, and on emission factors used. Uncertainties in the estimation of direct and indirect N_2O emissions from managed soils are caused by uncertainties related to activity data, emission factors, natural variability, partitioning fractions, lack of measurements, spatial aggregation, and lack of information on specific on-farm practices.

All calculated uncertainties of emission factors and activity data used are in accordance with methodology used in emission estimations, derived from the 2006 IPCC GLs. The detailed uncertainty values used in uncertainty assessment are presented under each source category described below. Results from uncertainty estimates from all categories can be seen in Annex III.

The time series was checked for consistency. In the next iteration, investigation will be performed with a view to collecting more accurate data.

5.1.5 Source specific recalculations

A recalculation has been done for this category because of some changes in activity data, addition of a new subcategory and improved activity data and emission factors. Thus, compared to earlier versions of the Mongolian GHG Inventory, the entire inventory can be considered as recalculated. In Table 5-5 shows the differences of GHG emissions estimated for iBUR and second BUR over time.

Table 5-5: Recalculated GHG emissions under the agriculture sector for the period 1990-2020, included in the iBUR and second BUR of the Mongolia, Gg CO_2e

Year	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
iBUR	10,585.30	10,407.34	10,348.57	10,021.88	10,807.34	11,719.79	12,067.63	13,093.45	13,423.70
BUR2	11,221.64	11,779.02	10,552.74	10,588.77	11,574.18	11,638.09	14,556.30	15,300.84	14,639.94
Diff. %	6.01	13.18	1.97	5.66	7.10	-0.70	20.62	16.86	9.06
Year	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
iBUR	13,525.34	11,790.52	9,224.50	8,485.01	8,646.21	9,265.37	9,881.33	11,133.62	12,729.74
BUR2	14,836.47	11,933.07	9,523.69	8,727.06	9,834.85	11,232.86	10,977.51	12,493.57	13,019.70
Diff. %	9.69	1.21	3.24	2.85	13.75	21.23	11.09	12.21	2.28
Year	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*		
iBUR	13,451.41	13,909.39	10,635.70	11,723.02	13,308.67	14,538.79	16,726.98		
BUR2	13,707.12	13,952.16	10,786.05	12,264.68	14,472.57	16,032.15	17,513.60		
Diff. %	1.90	0.31	1.41	4.62	8.75	10.27	4.70		

Abbreviations: iBUR-initial Biennial Update Report, BUR2-Second Biennial Update Report

5.1.6 Assessment of completeness

The current inventory covers greenhouse gas emissions from three categories such as Enteric fermentation (3.A.1), Manure management (3.A.2) and Aggregate sources and non-CO_2 emissions sources on land (3.C) estimated from 1990 to 2020. Table 5-6 shows the overview of the completeness status of estimations under various source categories within the sector.

Table 5-6: Assessment of completeness of GHG emissions under the agriculture sector

IPCC Category	*Source categories*	*Status of Gas*			
		CH_4	*N_2O*	*NO_x*	*CO*
3.A.1 - Enteric fermentation	3.A.1.a.ii – Other cattle	E	-	-	-
	3.A.1.c – Sheep	E	-	-	-
	3.A.1.d – Goats	E	-	-	-
	3.A.1.e – Camels	E	-	-	-
	3.A.1.f – Horses	E	-	-	-
	3.A.1.h – Swine	E	-	-	-
3.A.2 - Manure management	3.A.2.a.ii – Other cattle	E	NO	-	-
	3.A.2.c – Sheep	E	NO	-	-
	3.A.2.d – Goats	E	NO	-	-
	3.A.2.e – Camels	E	NO	-	-
	3.A.2.f – Horses	E	NO	-	-
	3.A.2.h – Swine	E	NO	-	-
	3.A.2.j – Poultry	E	NO	-	-
3.C - Aggregate sources and non-CO_2 emissions sources on land	3.C.1.a – Biomass burning in forest lands	E	E	E	E
	3.C.1.c – Biomass burning in croplands	NE	NE	NE	NE
	3.C.1.c – Biomass burning in grasslands	E	E	E	E
	3.C.1.c – Biomass burning in all other land	NE	NE	NE	NE
	3.C.2 – Liming	-	NO	NO	NO
	3.C.3 – Urea application		NO	NO	NO
	3.C.4 – Direct N_2O emissions from managed soils	-	E	NO	NO
	3.C.5 – Indirect N_2O emissions from managed soils	-	E	NO	NO
	3.C.6 – Indirect N_2O emissions from manure management	-	NO	NO	NO
	3.C.7 – Rive cultivation	NO	-	-	-
	3.C.8 – Other (please specify)	NO	-	NO	NO

Abbreviations: E-Estimated, source categories included in the inventory; NO-Not Occurring; NE-Not Estimated

5.1.7 Sector specific planned improvements

Mongolian livestock is a local indigenous breed of animals with very low productivity and small sized compared to the other breeds of animals in the world. Mongolia's animal husbandry has been nomadic pastoralist, with livestock herding on natural pasture, even in winter time. Additionally, Mongolia's livestock manure is almost 100 percent deposited on pastures and rangelands, thus, it tends to decompose under more aerobic conditions which produces less CH_4 and hence detailed research is needed to provide a clarification of this issue. Moreover, the climate in Mongolia influences the type of forage and the amount digested by livestock annually.

The emission from Enteric fermentation source category significantly contributes to national greenhouse gas inventory and it is a key category. Thus, the highest priority of planned improvements could include obtaining detailed country specific emission factor for livestock source categories to transfer Tier 2 method. The emission factors of CH_4 by the local experts (Namkhainyam et al., 2014) have been developed for Enteric fermentation and Manure management for Mongolian specific conditions. However, in previous submission, those developed EFs were not used due to high uncertainty of the input parameters used for estimation. To improve uncertainty during GCP/MON/016/CBT project were developed country specific (CS) emission factors for enteric fermentation of cattle by age and gender. Though, still the new CS emission factors were not able to be used in this submission because they required verifications and approvals from the authorized institutions.

Based on iBUR reviews, with support from JICA's project *"Project for capacity development to establish a national GHG inventory cycle of continuous improvement",* it has been developed the improvement plan including long and short lists for each GHG inventory sectors. Therefore, improvement lists in Table 5-7 are activities that should be considered for improving the GHG emissions estimation of agriculture sector in the near future.

Table 5-7: Planned improvements in the agriculture sector

Sector	*Description*
3. Livestock	To reassess and improve emission factors for enteric fermentation and manure management that were previously developed in order to apply the Tier 2 method.
3.A.1 Enteric fermentation	Since enteric fermentation is a key category, it is advisable to shift to higher tiers. It requires an enhanced characterization of livestock populations such as changes in feeding rations, animal genetics (improved high-productive breeds), and distance walked to obtain food, and water for both pasture and intensive farmed livestock.
3.A.2 Manure management	To obtain and use MCF, Bo, and VS values that reflect country's specific conditions
3. C.1 Emissions from biomass burning	To develop national estimates of the area burnt and the nature of the fires especially how they affect carbon dynamics (e.g. effects on tree mortality) to provide reliable data for the not only forest land but also for the grassland and cropland.
3.C.4 and 3.C.5 N_2O emissions from managed soils	To obtain country specific activity data of the annual synthetic N applications

5.2 Livestock (3.A)

Emissions from livestock are generated through Enteric fermentation and Manure management from domestic animals such as cattle, sheep, goats, camels, horses and swine. In 2020, the total emissions from livestock were 13,075.15 Gg CO_2e which represented 58.40% of the total agricultural emissions. In general, total livestock emissions showed an increasing trend from 6,485.89 Gg CO_2e in 1990 to 13,075.15 Gg CO_2e in 2020. The observed growing emission level was due to rising animal populations. However, sharp decrease of livestock number was observed twice in 1999-2002 and 2009-2010 which were explained by large number of livestock loss during the harsh winter season named "dzud" (the overview of the agricultural sector section). Thus, emissions from livestock were reduced in these years and then gradually increased back in next following years (Figure 5-3). Methane emissions from enteric fermentation and manure management were calculated for following main species of livestock such as cattle, sheep, goat, horse and camel, and in addition swine and poultry. In 2020, methane were dominantly emitted from enteric fermentation which were for cattle (36.66%), sheep (24.76%), goats (22.84%), horses (12.15%), camels (3.59%) and swine less than 1%; and methane emissions from manure management were for cattle (29.75%), sheep (18.89%), goats (19.17%), horses (28.06%), camels (3.81%) and others less than 1%.

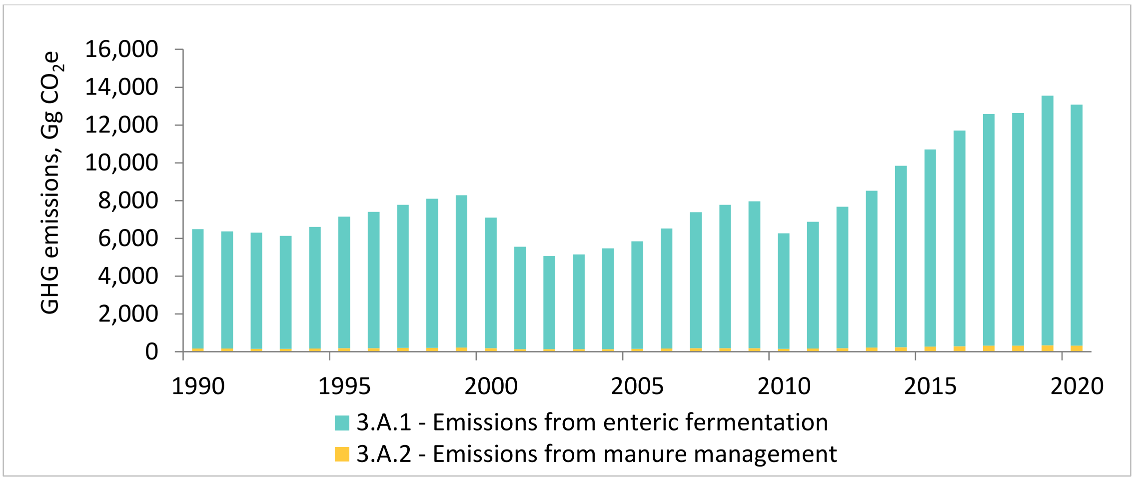

Figure 5-3: GHG emission trend from livestock

The annual emission estimation and percentage of the change trend by subcategories is given in the Table 5-8. In 2020, total emission from livestock was 101.59% higher than 1990 and 3.48% lower compared with 2019.

Table 5-8: Total CH_4 emissions from livestock category by source categories, 1990-2020, Gg CH_4 and Gg CO_2e

Year	*Enteric Fermentation*	*Manure Management*	*Livestock (Total CH_4)*	*Enteric Fermentation*	*Manure Management*	*Livestock total (Gg CO_2e)*
	Gg CH_4			*Gg CO_2e*		
1990	300.51	8.34	308.85	6,310.67	175.22	6,485.89
1991	295.14	8.11	303.25	6,197.84	170.31	6,368.15
1992	292.55	7.93	300.48	6,143.54	166.49	6,310.03
1993	284.13	7.70	291.83	5,966.73	161.61	6,128.34
1994	306.61	8.32	314.93	6,438.77	174.75	6,613.53
1995	331.70	9.03	340.73	6,965.65	189.64	7,155.29
1996	343.21	9.35	352.57	7,207.51	196.42	7,403.93
1997	360.40	9.81	370.21	7,568.46	205.98	7,774.44
1998	375.38	10.24	385.62	7,882.93	215.09	8,098.03
1999	384.21	10.50	394.71	8,068.33	220.60	8,288.93
2000	329.08	8.96	338.04	6,910.68	188.11	7,098.80
2001	257.50	7.10	264.60	5,407.56	149.14	5,556.70
2002	234.87	6.47	241.34	4,932.29	135.89	5,068.18
2003	238.57	6.54	245.11	5,009.97	137.39	5,147.36
2004	254.09	6.91	261.00	5,335.99	145.01	5,480.99
2005	271.29	7.29	278.58	5,697.09	153.17	5,850.26
2006	302.98	8.04	311.02	6,362.48	168.92	6,531.40
2007	343.04	8.99	352.03	7,203.79	188.78	7,392.57
2008	360.97	9.32	370.29	7,580.35	195.71	7,776.06
2009	369.55	9.52	379.07	7,760.63	199.83	7,960.46
2010	291.08	7.64	298.72	6,112.71	160.42	6,273.13
2011	318.93	8.38	327.31	6,697.47	176.02	6,873.49
2012	356.03	9.34	365.38	7,476.71	196.20	7,672.91
2013	395.20	10.40	405.60	8,299.27	218.43	8,517.70
2014	456.61	11.96	468.57	9,588.75	251.19	9,839.94
2015	496.64	13.00	509.64	10,429.36	273.00	10,702.36
2016	542.89	14.22	557.11	11,400.76	298.60	11,699.37
2017	584.46	15.32	599.78	12,273.60	321.75	12,595.35
2018	586.39	15.36	601.75	12,314.29	322.54	12,636.82
2019	628.66	16.44	645.10	13,201.90	345.22	13,547.12
2020	606.72	15.90	622.63	12,741.16	334.00	13,075.15
Diff. % 1990/2020	*101.90*	*90.60*	*1.02*	*101.90*	*90.60*	*101.59*
Diff. % 2019/2020	*-3.49*	*-3.26*	*-3.48*	*-3.49*	*-3.26*	*-3.48*

5.2.1 Enteric fermentation (3.A.1)

5.2.1.1 Category description

Methane is produced in herbivores as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream. The amount of methane that is released depends on the type of digestive tract, age, and weight of the animal, and the quality and quantity of the feed consumed. Ruminant livestock (e.g., cattle, sheep) are major sources of methane with moderate amounts produced from non-ruminant livestock (e.g., horses, pigs). The ruminant gut (rumen, reticulum, omasum, and abomasum) structure fosters extensive enteric fermentation of their diet (2006 IPCC GLs, Vol.4, Ch.10, page 10.24).

Methane emissions from the enteric fermentation category were identified among the largest key categories of Mongolia in the 2020 level assessment, and were also assessed as a key category in the trend assessment. The emissions were reported from other cattle (including dairy cows, other mature non-dairy cattle and growing cattle), sheep, goats, camels, horses, and swine.

The total emissions attributed to enteric fermentation was 12,741.16 Gg CO_2e making up 97.45% of the total livestock emissions, 56.90% of the agriculture emissions in 2020. In 1990, cattle contributed 44.55% of the total emissions from enteric fermentation. The rest were emitted as followed: sheep (25.10%), horses (13.55%), goats (8.53%), camels (8.23%) and swine (0.04%). By 2020, percentage share of the each livestock contribution to the enteric fermentation was changed as followed: cattle (36.66%), sheep (24.76%), goats (22.84%), horses (12.15%) and camels (3.59%).

Emissions from enteric fermentation increased by 101.9% (6,430.49 Gg CO_2e) between 1990 and 2020. Since 1990, there have been changes in relation to emissions sources within the enteric fermentation category. The largest increase came from emissions from goats (440.81% increase in enteric fermentation between 1990 and 2020), however, the decrease observed in emissions from camels and swine (Table 5-9).

Table 5-9: The enteric fermentation emissions by livestock types in 1990 and 2020

Subcategories	*Gg CO_2e*		*Change from 1990 (Gg CO_2e)*	*Change from 1990 (%)*	*Share of Enteric fermentation category (%)*		*Share of total Agriculture sector (%)*	
	1990	*2020*			*1990*	*2020*	*1990*	*2020*
3.A.1.a.ii – Other cattle	2,811.67	4,670.49	1,858.82	66.11%	44.55%	36.66%	25.06%	20.86%
3.A.1.c – Sheep	1,583.72	3,155.19	1,571.47	99.23%	25.10%	24.76%	14.11%	14.09%
3.A.1.d – Goats	538.2	2,910.63	2,372.43	440.81%	8.53%	22.84%	4.80%	13.00%
3.A.1.e – Camels	519.23	456.85	-62.38	-12.01%	8.23%	3.59%	4.63%	2.04%
3.A.1.f – Horses	855.04	1,547.48	692.44	80.98%	13.55%	12.15%	7.62%	6.91%
3.A.1.h – Swine	2.83	0.52	-2.31	-81.80%	0.04%	0.00%	0.03%	0.00%
3.A.1 - Enteric fermentation	6,310.67	12,741.16	6,430.49	101.90%	100.00%	100.00%	56.24%	56.90%

As explained in overview section, main driver of the emission fluctuation of the enteric fermentation between 1990 and 2020 is loss of livestock population during the natural disaster. Figure 5-4 shows the total methane emissions from enteric fermentation by livestock types for the entire inventory period.

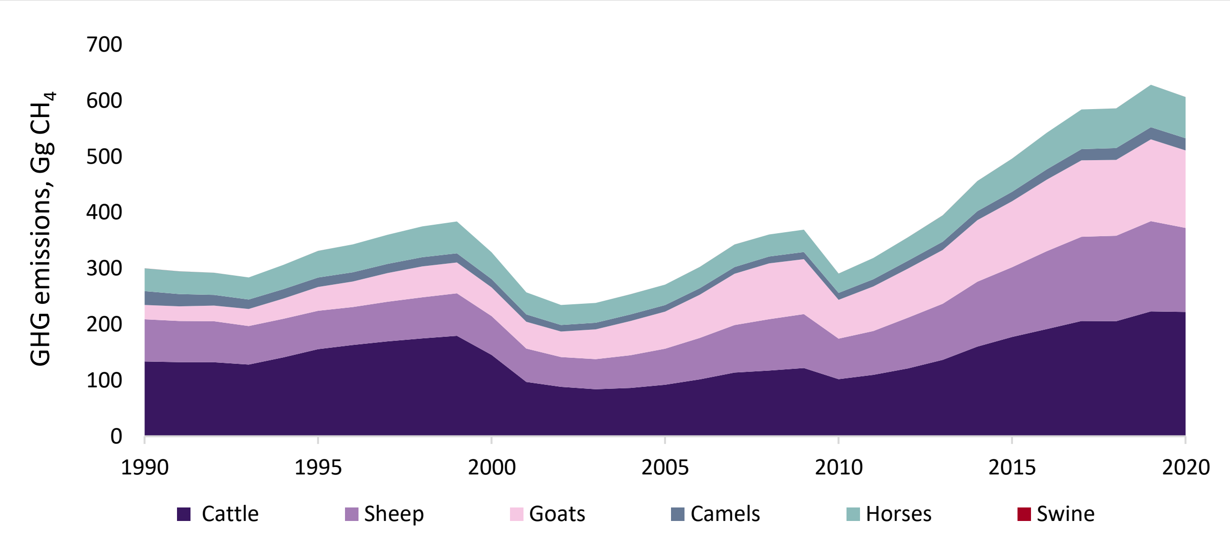

Figure 5-4: Total emission trend from enteric fermentation of livestock

During the inventory period the emission trend from each livestock category showed different pattern of changes compared with the base year. By 2020, the percentage of camel and swine decreased compared with 1990 year level, meanwhile the percentage of other categories such as cattle, sheep, goats, and horses has been increased (Table 5-10). These changes were demonstrated 101.90% increase from the 1990 level of 300.51 Gg CH_4 and 3.49% decrease from the 2019 level of 628.66 Gg CH_4. The reason for overall decrease of GHG emissions was due to i) drought occurred in summer of 2019 and 2020 in the most territories of the country, ii) following the drought a high risk of dzud which may cause, large number of livestock were preemptively slaughtered to prevent dzud risk.

Table 5-10: Breakdown of the CH_4 emissions from enteric fermentation by livestock subcategories, 1990-2020, Gg CH_4

Year	*Other Cattle*	*Sheep*	*Goats*	*Camels*	*Horses*	*Swine*	*Total Animal*
1990	133.89	75.42	25.63	24.73	40.72	0.13	300.51
1991	132.64	73.60	26.25	21.90	40.67	0.08	295.14
1992	132.50	73.29	28.01	19.10	39.60	0.05	292.55
1993	128.33	68.90	30.54	16.91	39.43	0.03	284.13
1994	141.24	68.93	36.21	16.84	43.36	0.02	306.61
1995	155.90	68.59	42.60	16.90	47.67	0.02	331.70
1996	163.39	67.80	45.67	16.46	49.87	0.02	343.21
1997	169.80	70.83	51.33	16.35	52.08	0.02	360.40
1998	175.11	73.47	55.31	16.40	55.06	0.02	375.38
1999	179.76	75.96	55.17	16.36	56.94	0.02	384.21
2000	145.59	69.38	51.35	14.85	47.89	0.01	329.08
2001	97.27	59.69	47.96	13.12	39.45	0.01	257.50
2002	88.56	53.18	45.67	11.64	35.80	0.01	234.87
2003	84.26	53.78	53.26	11.81	35.44	0.01	238.57
2004	86.56	58.43	61.19	11.80	36.10	0.02	254.09
2005	92.29	64.42	66.34	11.69	36.52	0.02	271.29
2006	101.89	74.08	77.26	11.65	38.07	0.03	302.98
2007	114.01	84.95	91.74	11.99	40.31	0.04	343.04
2008	117.66	91.81	99.85	12.26	39.36	0.03	360.97
2009	122.17	96.37	98.26	12.74	39.98	0.03	369.55
2010	102.27	72.40	69.42	12.40	34.57	0.02	291.08
2011	109.97	78.34	79.67	12.88	38.03	0.03	318.93
2012	121.48	90.71	87.79	14.07	41.95	0.04	356.03
2013	136.74	100.33	96.14	14.79	47.15	0.05	395.20
2014	160.45	116.07	110.04	16.07	53.92	0.05	456.61
2015	177.68	124.72	117.96	16.93	59.32	0.03	496.64

2016	191.80	139.28	127.87	18.46	65.44	0.03	542.89
2017	206.26	150.55	136.73	19.97	70.92	0.03	584.46
2018	205.90	152.77	135.62	21.15	70.92	0.03	586.39
2019	223.40	161.34	146.31	21.73	75.87	0.02	628.66
2020	222.40	150.25	138.60	21.75	73.69	0.02	606.72
Diff% 1990/2020	66.11	99.23	440.81	-12.01	80.98	-81.79	101.90
Diff% 2019/2020	-0.45	-6.87	-5.27	0.12	-2.87	17.42	-3.49

5.2.1.2 Methodological issues

5.2.1.2.1 Choice of method

Emissions from enteric fermentation were calculated at Tier 1, following the 2006 IPCC GLs, Vol. 4, Ch. 10 methodology according to the formula:

$$Emission = AD * EF$$

Where:

Emission = GHG emissions, in kg CH_4 yr^{-1};

AD = Activity data, representing the number of livestock in heads;

EF = Tier 1, default IPCC emission factors, expressed in units of kg CH_4 $head^{-1}$ yr^{-1}.

5.2.1.2.2 Activity data

The dominant livestock sector contributes 84.9% of total agricultural production. In accordance with the Article 7.1 Law on Statistics of Mongolia, the Law on Administration, Territorial Units and Their Management, and Resolution No. 224 of the Government of Mongolia of 2003, the National Statistics Office (NSO) conducts the annual nationwide census of livestock and domestic animals from 7-17 December covering all individual herders, families and business entities operating livestock farming. The livestock census used to conducted mostly in August and September but, since 1961 it has been changed to December which allows a complete yearly estimation of GHG emissions.

The number of livestock heads between 1990 and 2020 are given in Table 5-11 by animal subcategory, provided by the National Statistics Office (NSO). In terms of livestock flocks, sheeps account for 44.80% of the total number of livestock, goats for 41.33%, cattle for 7.06%, horses for 6.10% and camels for 0.71%. Traditionally, the proper ratio between sheep and goat was set at 75:25, but the ratio was 52:48 in 2020.

Table 5-11: Mongolian animal population within 1990-2020, thousand heads

Year	*Cattle*	*Horses*	*Camels*	*Sheep*	*Goats*	*Total livestock*	*Swine*	*Poultry* (AAP)*	*Total animal*
1990	2,848.70	2,262.00	537.50	15,083.00	5,125.70	25,856.90	134.69	53.62	26,045.21
1991	2,822.04	2,259.34	475.99	14,720.98	5,249.57	25,527.90	83.27	36.71	25,647.89
1992	2,819.21	2,200.18	415.15	14,657.01	5,602.53	25,694.09	48.56	30.25	25,772.89
1993	2,730.46	2,190.33	367.67	13,779.19	6,107.04	25,174.69	28.66	21.63	25,224.98
1994	3,005.18	2,408.86	366.14	13,786.61	7,241.31	26,808.10	23.42	12.18	26,843.70
1995	3,317.04	2,648.43	367.49	13,718.61	8,520.73	28,572.31	23.51	16.32	28,612.14
1996	3,476.29	2,770.47	357.92	13,560.59	9,134.86	29,300.12	19.09	9.54	29,328.75

1997	3,612.85	2,893.15	355.37	14,165.62	10,265.31	31,292.30	20.71	10.70	31,323.71
1998	3,725.83	3,059.06	356.53	14,694.25	11,061.86	32,897.53	19.87	10.94	32,928.34
1999	3,824.67	3,163.45	355.59	15,191.30	11,033.89	33,568.90	21.86	12.84	33,603.60
2000	3,097.61	2,660.72	322.91	13,876.43	10,269.84	30,227.50	14.68	14.65	30,256.83
2001	2,069.59	2,191.84	285.23	11,937.35	9,591.33	26,075.34	14.77	8.94	26,099.05
2002	1,884.28	1,988.90	253.03	10,636.60	9,134.76	23,897.57	13.29	10.13	23,920.99
2003	1,792.77	1,968.90	256.73	10,756.38	10,652.93	25,427.70	13.73	14.89	25,456.32
2004	1,841.61	2,005.29	256.61	11,686.44	12,237.99	28,027.95	17.18	29.16	28,074.29
2005	1,963.65	2,029.07	254.20	12,884.54	13,267.38	30,398.83	22.68	23.29	30,444.80
2006	2,167.91	2,114.75	253.29	14,815.08	15,451.67	34,802.70	32.76	34.84	34,870.30
2007	2,425.83	2,239.50	260.58	16,990.08	18,347.84	40,263.84	35.97	48.53	40,348.35
2008	2,503.42	2,186.94	266.42	18,362.35	19,969.39	43,288.51	29.29	59.15	43,376.95
2009	2,599.33	2,221.31	277.05	19,274.73	19,651.52	44,023.95	25.81	65.66	44,115.42
2010	2,176.00	1,920.34	269.58	14,480.40	13,883.21	32,729.53	24.84	70.00	32,824.37
2011	2,339.70	2,112.93	280.06	15,668.53	15,934.56	36,335.78	30.40	98.11	36,464.29
2012	2,584.62	2,330.43	305.84	18,141.36	17,558.67	40,920.92	40.42	77.16	41,038.50
2013	2,909.46	2,619.38	321.48	20,066.43	19,227.58	45,144.32	51.86	80.43	45,276.62
2014	3,413.85	2,995.75	349.30	23,214.78	22,008.90	51,982.58	46.31	130.61	52,159.50
2015	3,780.40	3,295.34	367.99	24,943.13	23,592.92	55,979.78	33.49	132.36	56,145.64
2016	4,080.94	3,635.49	401.35	27,856.60	25,574.86	61,549.24	31.49	118.14	61,698.86
2017	4,388.46	3,939.81	434.10	30,109.89	27,346.71	66,218.96	31.87	115.90	66,366.73
2018	4,380.88	3,940.09	459.70	30,554.80	27,124.70	66,460.18	27.82	145.65	66,633.65
2019	4,753.19	4,214.82	472.38	32,267.27	29,261.66	70,969.32	20.89	147.73	71,137.94
2020	4,732.01	4,093.86	472.93	30,049.43	27,720.25	67,068.49	24.53	163.92	67,256.93
Diff% 1990/2020	66.11	80.98	-12.01	99.23	440.81	159.38	-81.79	205.69	158.23
Diff% 2019/2020	-0.45	-2.87	0.12	-6.87	-5.27	-5.50	17.42	10.95	-5.46

** annual average population of poultry was estimated according to equation 10.1 (the 2006 IPCC GLs)*
Source: Statistical Yearbooks of Agriculture 1990-2020; NSO, 2021a; NSO - www.1212.mn

Activity data cover the following animal categories: cattle, horses, camels, sheep, goats, swine and poultry. For the period between 1990 and 2020, the activity data are taken from Statistical yearbooks of agriculture for 1990-2020. For dairy cattle, in Mongolia,specialized dairy cattle breeds are still rare (<1%), and female cattles are more appropriately categorized as 'other cattle'. Therefore, all cattles of Mongolia are considered as other cattle. Broiler chickens are typically raised for approximately 60 days before the slaughter. In order to avoid overestimation, annual average population of poultry is estimated according to equation 10.1 (the 2006 IPCC GLs) and estimated numbers are entered in the Table 5-6. However, emissions from poultry enteric fermentation have not been estimated. According to the 2006 IPCC GLs, methodology for enteric fermentation calculation from poultry is not developed. Methane emissions from poultry are included only in the manure management category.

5.2.1.2.3 Emission factors and other parameters

The CH_4 emission factors are specified by livestock category and regional grouping in the 2006 IPCC GLs, Vol. 4, Ch. 10, Tables 10.10 and 10.11. The emission factors listed under Asia region are chosen for Mongolia (Table 5-12).

Table 5-12: Default EFs used to estimate CH_4 emissions from enteric fermentation

Livestock category	*Emission factors, kg CH_4/head/year*	*Average live weight, kg*	*Typical animal mass, kg*	*Reference*
*Other cattle**	47	*	319	IPCC 2006 GLs, Vol. 4, Ch. 10, Tables 10.10 and 10.11
Sheep	5	45	28	
Goats	5	40	30	
Horses	18	550	238	
Camels	46	570	217	
Swine	1.0		28	

** Other cattle includes multi-purpose cows, bulls and young*

5.2.1.2.4 Uncertainties and time series consistency

Uncertainties related to the estimation of methane emissions from the enteric fermentation, in particular, depend on the accuracy of the livestock characteristics, and also on the default emission factors used. The 2006 IPCC GLs recommended default values were used as a source of uncertainty. However, an expert judgment was performed to choose values applicable for GHG emission calculations from this subcategory and they are presented in Table 5-13. The uncertainty associated with livestock populations will widely vary depending on its type, but should be known within ±10% (2006 IPCC GLs, Vol.4, Ch.10, page 10.23). As the emission factors for the Tier 1 method are not based on the country specific data, they may not accurately represent a country's livestock characteristics and a result may be highly uncertain. Emission factors of enteric fermentation estimated using the Tier 1 method are to be known more accurately than ±30% and may be uncertain up to ±50% (2006 IPCC GLs, Vol.4, Ch.10, page 10.33). The time series was checked for the consistency.

Table 5-13: Estimated values of uncertainties used in enteric fermentation

Input	*Uncertainties*
Activity data	
Livestock population (cattle, sheep, goats, horses, camels and swine)	±10%
Emission factor	
Enteric fermentation (CH_4) (cattle, swine)	±30%
Enteric fermentation (CH_4) (sheep, goats, horses, camels and swine)	±40%

5.2.1.3 Category-specific recalculations

There have been no recalculations of emissions for this category.

5.2.1.4 Category-specific planned improvements

During the next sequence of GCP/MON/016/CBT project, considering to develop country-specific emission factors for enteric fermentation by each livestock types in Mongolia to apply next iteration.

5.2.2 Manure management (3.A.2)

5.2.2.1 Category description

GHG emissions from manure management consist of methane (CH_4) and nitrous oxide (N_2O) gases from aerobic and anaerobic manure decomposition processes. The term 'manure' is used here collectively include both dung and urine produced by livestock. The emissions level depends on the amount of manure treated and handled within manure management systems and type of manure management systems.

The main manure management systems covered by this inventory were pasture/range/paddock for the cattle, sheep, goats, horses and camels, and a daily spread system of the swine and poultry. For these two systems, N_2O emissions during manure storage and treatment are assumed to be zero, and N_2O emissions from land application of Mongolian livestock are covered under the Aggregate sources and non-CO_2 emissions sources on land (3.C) source category. Thus, only CH_4 emissions were reported under the source category Manure management (3.A.2).

Table 5-14: Each livestock contribution to emissions from manure management in 1990 and 2020

Subsector	*Gg CO_2e*		*Change from 1990 (Gg CO_2e)*	*Change from 1990 (%)*	*Share of Manure management category (%)*		*Share of total Agriculture sector (%)*	
	1990	*2020*			*1990*	*2020*	*1990*	*2020*
3.A.2.a.ii – Other cattle	59.82	99.37	39.55	66.12%	34.14%	29.75%	3.01%	4.92%
3.A.2.c – Sheep	31.67	63.1	31.43	99.24%	18.07%	18.89%	1.59%	3.12%
3.A.2.d – Goats	11.84	64.03	52.19	440.79%	6.76%	19.17%	0.59%	3.17%
3.A.2.e – Camels	14.45	12.71	-1.74	-12.04%	8.25%	3.81%	0.73%	0.63%
3.A.2.f – Horses	51.78	93.71	41.93	80.98%	29.55%	28.06%	2.60%	4.64%
3.A.2.h – Swine	5.66	1.03	-4.63	-81.80%	3.23%	0.31%	0.28%	0.05%
3.A.2.j – Poultry	0.01	0.03	0.02	200.00%	0.01%	0.01%	0.00%	0.00%
3.A.2 – Manure management	175.23	334.00	158.77	90.61%	100.00%	100.00%	8.81%	16.53%

The total emissions attributed to manure management was 334.00 Gg CO_2e making up 2.55% of the total livestock emissions in 2020. Emissions from agriculture in 2020 were 90.60% higher compared with 1990, and about 3.26% lower compared with 2019 (Table 5-14). Main driver of fluctuation in the emissions from manure management between 1990 and 2020 is the loss of livestock population during the natural disaster (see Table 5-11). Figure 5-5 shows the total methane emissions from manure management by livestock type.

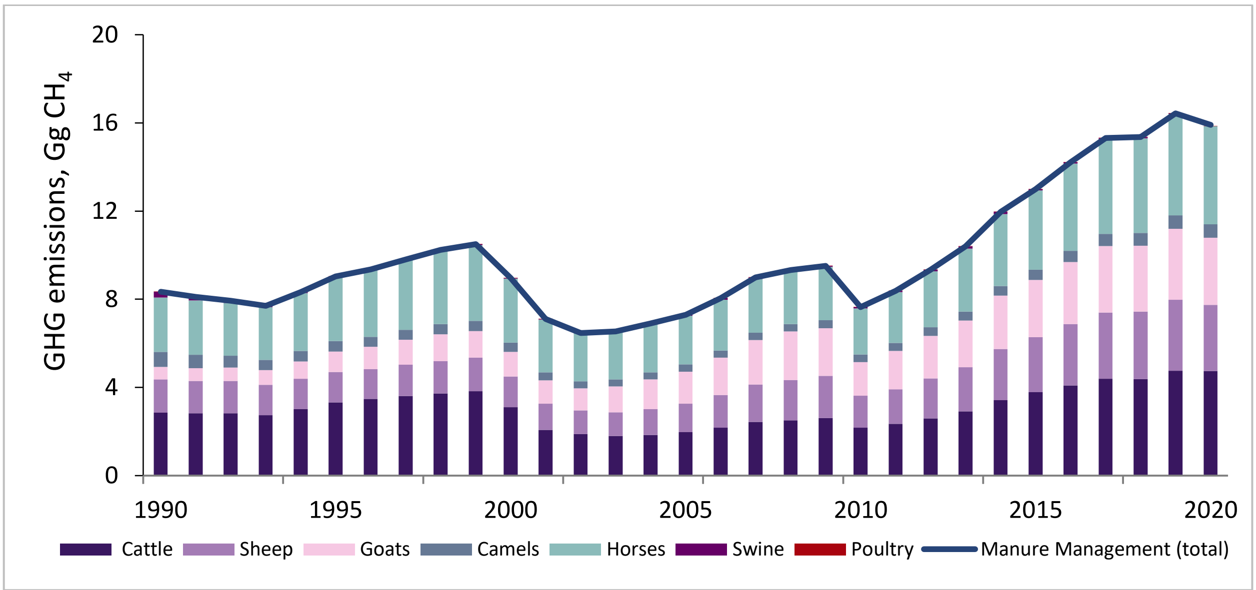

Figure 5-5: Total emission trend from manure management of livestock

In 1990, cattle contributed 34.14% of the total emissions from manure management (Figure 5-6). The rest were as follows: horses (29.55%), sheep (18.07%), camels (8.25%), goats (6.76%), swine (3.23%) and poultry (0.01%). By 2020, percentage share of the each livestock contribution to emissions from the manure management were as follows: cattle (29.75%), horses (28.06%), goats (19.17%), sheep (18.89%), camels (0.31%), swine (0.31%) and poultry (0.01%).

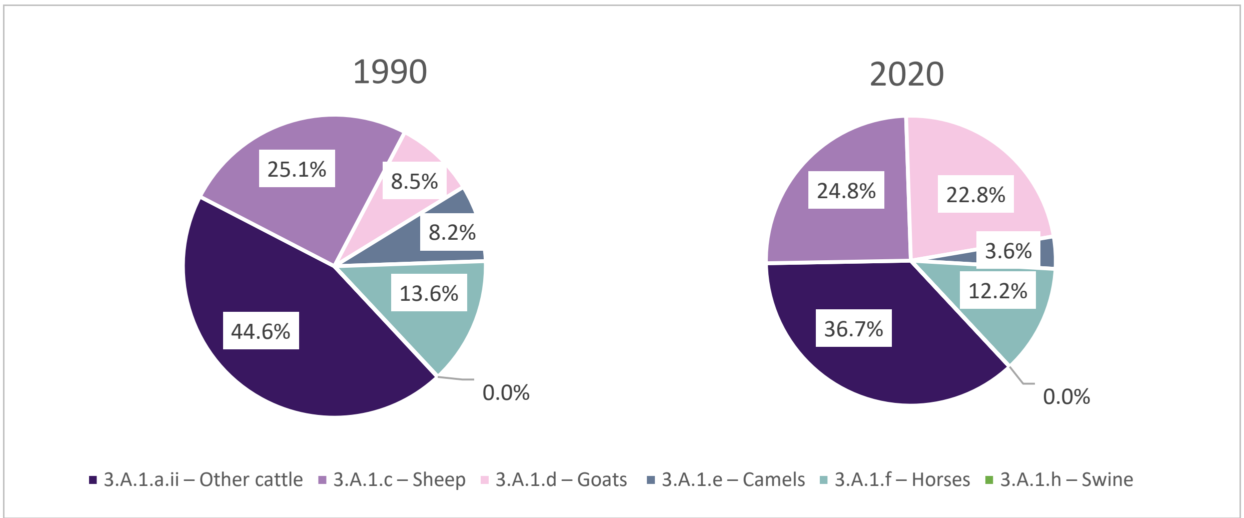

Figure 5-6: Each livestock contribution to the manure management emission in 1990 and 2020

Over the period under review, emission trend from each livestock category showed different pattern of change comparing with the base year. By 2020, the percentage of such categories as camel and swine decreased compared to 1990 year level, while the percentage of other categories such as cattle, sheep, goats, horses and poultry increased (Table 5-15).

Table 5-15: Breakdown of the CH_4 emissions from manure management by livestock category for the period 1990-2020, Gg CH_4

Year	*Other Cattle*	*Sheep*	*Goats*	*Camels*	*Horses*	*Swine*	*Poultry* (AAP)*	*Total animal*
1990	2.85	1.51	0.56	0.69	2.47	0.27	0.00054	8.34
1991	2.82	1.47	0.58	0.61	2.46	0.17	0.00037	8.11
1992	2.82	1.47	0.62	0.53	2.40	0.10	0.00030	7.93
1993	2.73	1.38	0.67	0.47	2.39	0.06	0.00022	7.70
1994	3.01	1.38	0.80	0.47	2.63	0.05	0.00012	8.32
1995	3.32	1.37	0.94	0.47	2.89	0.05	0.00016	9.03
1996	3.48	1.36	1.00	0.46	3.02	0.04	0.00010	9.35
1997	3.61	1.42	1.13	0.45	3.15	0.04	0.00011	9.81
1998	3.73	1.47	1.22	0.46	3.33	0.04	0.00011	10.24
1999	3.82	1.52	1.21	0.46	3.45	0.04	0.00013	10.50
2000	3.10	1.39	1.13	0.41	2.90	0.03	0.00015	8.96
2001	2.07	1.19	1.06	0.37	2.39	0.03	0.00009	7.10
2002	1.88	1.06	1.00	0.32	2.17	0.03	0.00010	6.47
2003	1.79	1.08	1.17	0.33	2.15	0.03	0.00015	6.54
2004	1.84	1.17	1.35	0.33	2.19	0.03	0.00029	6.91
2005	1.96	1.29	1.46	0.33	2.21	0.05	0.00023	7.29
2006	2.17	1.48	1.70	0.32	2.31	0.07	0.00035	8.04
2007	2.43	1.70	2.02	0.33	2.44	0.07	0.00049	8.99
2008	2.50	1.84	2.20	0.34	2.38	0.06	0.00059	9.32
2009	2.60	1.93	2.16	0.35	2.42	0.05	0.00066	9.52
2010	2.18	1.45	1.53	0.35	2.09	0.05	0.00070	7.64
2011	2.34	1.57	1.75	0.36	2.30	0.06	0.00098	8.38
2012	2.58	1.81	1.93	0.39	2.54	0.08	0.00077	9.34
2013	2.91	2.01	2.12	0.41	2.86	0.10	0.00080	10.40
2014	3.41	2.32	2.42	0.45	3.27	0.09	0.00131	11.96
2015	3.78	2.49	2.60	0.47	3.59	0.07	0.00132	13.00

2016	4.08	2.79	2.81	0.51	3.96	0.06	0.00118	14.22
2017	4.39	3.01	3.01	0.56	4.29	0.06	0.00116	15.32
2018	4.38	3.06	2.98	0.59	4.29	0.06	0.00146	15.36
2019	4.75	3.23	3.22	0.60	4.59	0.04	0.00148	16.44
2020	4.73	3.00	3.05	0.61	4.46	0.05	0.00164	15.90
Diff% 1990/2020	66.11	99.23	440.81	-12.01	80.98	-81.79	205.69	90.60
Diff% 2019/2020	-0.45	-6.87	-5.27	0.12	-2.87	17.42	10.95	-3.26

5.2.2.2 Methodological issues

5.2.2.2.1 Choice of method

Emissions from manure management were calculated at Tier 1, following 2006 IPCC GLs, Vol. 4, Ch. 10 methodology according to the formula:

$$Emission = AD * EF$$

Where:

Emission = GHG emissions, in kg CH_4 yr^{-1};

AD = Activity data, representing the number of livestock in heads;

EF = Tier 1, default IPCC emission factors, expressed in units of kg CH_4 $head^{-1}$ yr^{-1}.

5.2.2.2.2 Activity data

Activity data cover the following animal categories: cattle, horses, camels, sheep, goats, swine and poultry. The activity data are taken from Statistical yearbooks of agriculture for 1990-2020. For dairy cattle, in Mongolia, specialized dairy breeds are still rare (<1%), therefore, all females are more appropriately categorized as 'other cattle'. Therefore, all cattle of Mongolia are taken as 'other cattle'. Broiler chickens are typically raised approximately 60 days prior to slaughter. In order to avoid overestimation, annual average population of poultry was estimated using by equation 10.1 in the 2006 IPCC GLs, Vol. 4, Ch. 10 methodologies and estimated numbers are entered in the Table 5-11.

5.2.2.2.3 Emission factors and other parameters

The 2006 IPCC GLs Tier 1 method and default emission factors were used for estimation of GHG emissions from manure management. The EF values are specified by livestock category and regional grouping in the 2006 IPCC GLs, Vol. 4, Ch. 10, Tables 10A-5, Tables 10A-8 and 10A-9. The EF listed under Asia region with average annual temperature ($\leqslant 10^oC$) are chosen for the Mongolia (Table 5-16). The share of the individual animal manure management systems common in Mongolia were estimated by expert judgment and categorized by animal type.

The dimensionless conversion factors used are:

- 10^{-6}, to convert the emissions from kg CH_4 to Gg CH_4; and
- GWP-CH_4 = 21 (100-year time horizon global warming potential provided by the IPCC in its Second Assessment Report), to convert Gg CH_4 to Gg CO_2e (17/CP.8, Annex, paragraph 20).

Table 5-16: Default emission factors and other parameters used to estimate CH_4 emissions from manure management

Livestock category	*Typical animal mass (kg)*	*Excretion rate per mass per day [kg N/(animal yr)]*	*Manure management system (MMS)*	*Fraction of MMS*	*MMS EF*	*Reference*
Cattle	319	0.34	Pasture/Range/ Paddock	1	1.00	IPCC 2006 GLs, Vol. 4, Ch. 10, Tables 10A-5
Sheep	28	1.17		1	0.10	IPCC 2006 GLs, Vol. 4, Ch. 10, Tables 10A-9
Goats	30	1.37		1	0.11	IPCC 2006 GLs, Vol. 4, Ch. 10, Tables 10A-9
Horses	238	0.46		1	1.09	IPCC 2006 GLs, Vol. 4, Ch. 10, Tables 10A-9
Camels	217	0.46		1	1.28	IPCC 2006 GLs, Vol. 4, Ch. 10, Tables 10A-9
Swine	28	0.24	Daily spread	1	2.00	IPCC 2006 GLs, Vol. 4, Ch. 10, Tables 10A-8
Poultry AAP	-	0.82		1	0.01	IPCC 2006 GLs, Vol. 4, Ch. 10, Tables 10A-9

5.2.2.2.4 Source specific uncertainties and time series consistency

Uncertainties related to the estimation of methane emissions from manure management, in particular, depend on the accuracy of the livestock characteristics, and on the default emission factors used. The 2006 IPCC GLs recommended default values were used as the source of uncertainty values. However, expert judgment was performed to choose values applicable for GHG emission calculations from this subcategory which are presented in Table 5-17. The uncertainty associated with livestock populations will vary widely depending the on type of source, but should be known within ±10% (2006 IPCC GLs, Vol. 4, Ch. 10, page 10.23). The uncertainties for default emission factors were taken from the 2006 IPCC GLs, Vol. 4, Ch. 10, page 10.48. The time series was checked for consistency.

Table 5-17: Estimated values of uncertainties used in manure management

Input	*Uncertainties*
Activity data	
Animal population (cattle, sheep, goats, horses, camels and swine)	±10%
Emission factor	
Manure management (CH_4) (cattle, sheep, goats, horses and camels)	±10%
Manure management (CH_4) (swine, poultry)	±30%
Manure management system:	
Pasture/range and paddock	±10%
Daily speed	±25%

5.2.2.3 Category-specific recalculations

There have been no recalculations of emissions done for this category.

5.2.2.4 Category-specific planned improvements

Since this category is not identified as a key category, improvement is not prioritized

5.3 Aggregate sources and non-CO_2 emission sources from land (3.C)

Emissions of this category, CH_4 and N_2O from biomass burning, direct and indirect N_2O from managed soils, are reported in this category.

Different sources of N_2O from managed soils are distinguished in the IPCC methodology, namely:

- Direct emissions from managed soils (from use of synthetic fertilizers; animal excreta nitrogen, sewage sludge and other organic fertilizers applied to soils, droppings from grazing animals, crop residues and cultivation of soils with a high organic content).
- N_2O emissions indirectly induced by agricultural activities (N losses by volatilization, leaching and run-off).

In 2020, the total GHG emissions from this source category were 9,315.42 Gg CO_2e representing 41.60% of the total emissions of agriculture sector.

In general, emissions from the total 3C - Aggregate sources and non-CO_2 emissions sources on land subsector, showed an increasing trend from 4,735.74 Gg CO_2e in 1990 to 9,315.42 Gg CO_2e in 2020. The observed increasing level of GHG emissions was mainly due to rising animal populations which directly causes the increased amount of manure deposited on the pasture.

However, there were a sharp decrease of the livestock number occurred twice in 1999-2002 and 2009-2010 due to high number of livestock loss during the dzud which is explained in details in the overview section of the agricultural sector. Thus, N_2O emissions from managed soils during these years declined and gradually increased back in the next following years. The emissions for the aggregate sources and non-CO_2 emissions sources on land category breakdown by source categories, expressed in percentage, is presented in the Table 5-18.

Table 5-18: Breakdown of the Aggregate sources and non-CO_2 emissions sources on land category CH_4 and N_2O emissions by source category, 1990-2020, Gg CO_2e

Categories	*Unit*	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*
3.C.1 - Emissions from biomass burning	Gg CO_2e	731.39	34.72	305.49	1,095.21	139.20	1,621.40	142.25
	%	15.44	0.77	6.32	21.36	3.08	17.85	1.53
3.C.4 - Direct N_2O Emissions from managed soils	Gg CO_2e	2,984.13	3,316.34	3,359.35	2,945.00	3,202.31	5,465.62	6,729.39
	%	63.01	73.98	69.49	57.44	70.96	60.16	72.24
3.C.5 - Indirect N_2O Emissions from managed soils	Gg CO_2e	1,020.23	1,131.73	1,169.42	1,087.03	1,171.40	1,998.47	2,443.77
	%	21.54	25.25	24.19	21.20	25.96	22.00	26.23
3.C – Aggregate sources and non-CO_2 emissions sources on land	Gg CO_2e	4,735.74	4,482.79	4,834.27	5,127.24	4,512.90	9,085.48	9,315.42
	%	100	100	100	100	100	100	100

Figure 5-7 shows the percentage comparison between each source category of aggregate sources and non-CO_2 emission sources on land for the period 1990 and 2020. Direct N_2O emissions from managed soils is the dominant source (72.24%) within the category. In 2020, urine and dung N deposited on pasture, range and paddock by grazing animals contributed the major part of total direct N_2O emissions (96.33%), following by emission from animal manure applied to soils (4.6%), synthetic fertilizers (3.1%), crop residues (0.55%), and other organic N additions applied to soils (0.004%).

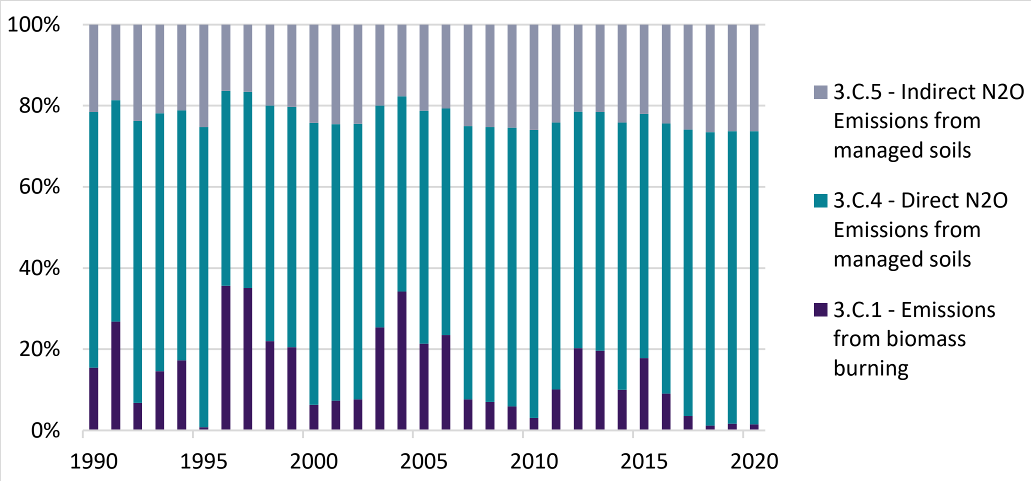

Figure 5-7: Each subcategory contribution to the Aggregate sources and non-CO_2 emissions sources on land category

5.3.1 Biomass burning (3.C.1)

5.3.1.1 Category description

Despite the large inherent spatial and temporal variability of fire (in particular that from wildfires), countries should estimate and report greenhouse gas emissions from fire on an annual basis.

Both uncontrolled (wildfires) and managed (prescribed) fires can have a major impact on the non-CO_2 emission from forests. This category included biomass burning that consists of CH_4, N_2O, NO_x and CO emissions from biomass combustion of forest land and grasslands. Emissions from other lands are excluded due to unavailability of data activity on those burned area, if exists.

Fire is treated as a disturbance that affects not only the biomass (in particular, above-ground) but also the dead organic matter (litter and deadwood), especially, in forest ecosystems. For grassland having little woody vegetation, reference is usually made to biomass burning, since biomass is the main pool affected by the fire.

The total emissions attributed to biomass burning was 142.25 Gg CO_2e making up 1.53 % of the total aggregated sources and non-CO_2 emission sources on land emissions in 2020, which was 80.55% and 11.81% lower than 1990 and 2019 levels, respectively (Table 5-19). In 2020, emissions from biomass burning were 60.83% and 39.17% in forest land and grasslands, respectively. The share of N_2O emissions is represented 49.83% and CH_4 emissions is 50.17% from the biomass burning in 2020.

Table 5-19: Total GHG emissions from biomass burning within 1990-2020 periods

Year	*3.C.1 - Emissions from biomass burning*				*3.C.1 - Emissions from biomass burning (CO_2e)*		
	CH_4 (Gg)	*N_2O (Gg)*	*NO_x (Gg)*	*CO(Gg)*	*CH_4 (Gg CO_2e)*	*N_2O (Gg CO_2e)*	*Total (Gg CO_2e)*
1990	15.61	1.30	22.84	422.31	327.82	403.68	731.50
1991	29.55	2.68	49.68	832.95	620.58	831.88	1,452.46
1992	5.94	0.52	9.53	373.99	124.79	162.56	287.35
1993	13.44	1.19	21.66	373.99	282.27	368.40	650.68
1994	17.57	1.57	28.76	491.11	368.93	486.34	855.27
1995	0.88	0.05	0.67	20.61	18.51	16.06	34.58
1996	55.87	4.45	75.49	1,478.87	1,173.21	1,378.20	2,551.41
1997	55.49	4.76	84.96	1,520.70	1,165.27	1,474.27	2,639.54
1998	31.33	2.52	42.98	832.68	657.91	779.81	1,437.71

1999	27.97	2.43	43.90	772.01	587.27	754.26	1,341.53
2000	7.40	0.48	6.92	179.89	155.42	150.24	305.65
2001	7.22	0.45	6.10	172.09	151.58	139.57	291.15
2002	6.97	0.43	5.87	166.11	146.41	134.42	280.82
2003	26.27	2.06	34.64	690.92	551.63	639.07	1,190.69
2004	40.77	3.59	65.35	1,132.57	856.21	1,114.05	1,970.26
2005	22.98	1.98	35.37	630.83	482.68	612.68	1,095.36
2006	29.39	2.53	45.31	807.02	617.13	784.05	1,401.18
2007	10.18	0.70	10.59	253.09	213.86	217.87	431.73
2008	10.13	0.65	9.16	244.60	212.72	202.25	414.96
2009	8.97	0.54	6.97	210.76	188.44	166.97	355.41
2010	3.30	0.23	3.36	81.70	69.39	69.94	139.33
2011	11.34	0.99	17.91	313.62	238.13	307.11	545.25
2012	29.42	2.44	42.78	794.55	617.86	757.86	1,375.72
2013	30.74	2.67	48.22	848.54	645.62	828.82	1,474.44
2014	15.72	1.41	25.87	440.15	330.12	436.51	766.63
2015	33.18	2.98	54.89	930.54	696.78	924.61	1,621.39
2016	17.32	1.46	25.87	471.28	363.72	453.19	816.91
2017	7.36	0.55	8.99	189.90	154.61	171.57	326.17
2018	2.74	0.16	1.97	63.57	57.62	49.45	107.07
2019	3.86	0.26	3.80	94.80	81.05	80.32	161.37
2020	3.40	0.23	3.36	83.58	71.36	70.89	142.25
Diff. % 1990/2020	-78.23	-82.44	-85.29	-80.21	-78.23	-82.44	-80.55
Diff. % 2019/2020	-11.95	-11.67	-11.58	-11.84	-11.95	-11.67	-11.81

*Note: *- NOx and CO emissions doesn't included in total emissions from biomass burning*

GHG emission of biomass burning is shown in Figure 5-8. Fluctuations in the area burnt are caused mainly by the weather conditions of the years (e.g. extremely windy and dry springs).

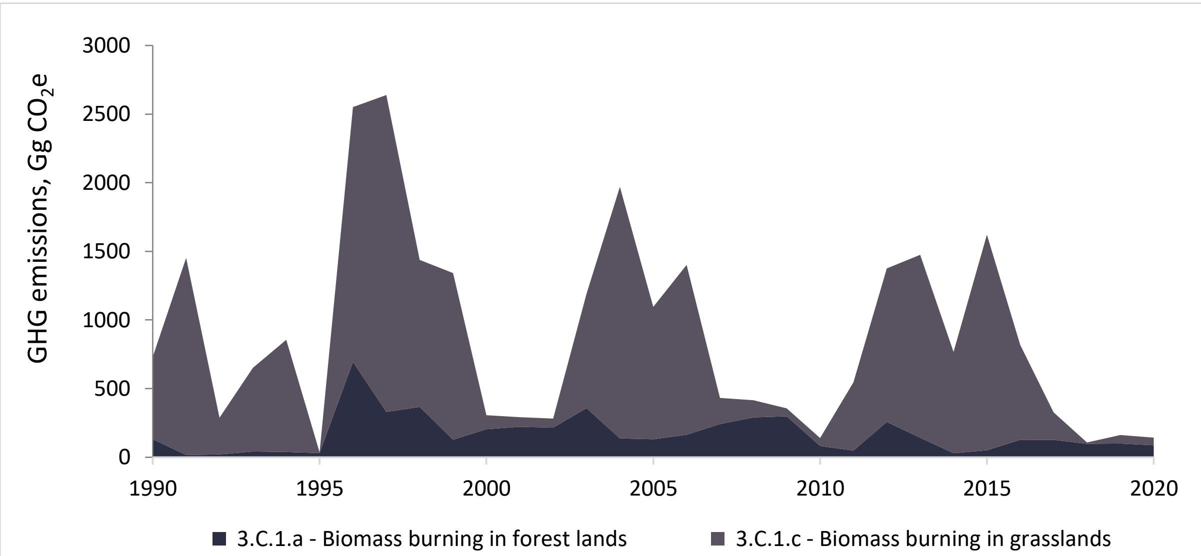

Figure 5-8: GHG emissions of biomass burning, Gg

5.3.1.2 Methodological issues

For Mongolia, for estimation of emissions from forest fire used the country-specific activity data and emission factors of Tier 2 method. For prescribed fires, country-specific data are required to generate reliable estimates of emissions, since activity data, in general, are poorly reflected in global data sets. However, Mongolia does not have prescribed fires and therefore all fires are considered wildfires.

5.3.1.2.1 Choice of method

The emissions from burning of biomass combustion of forest land and grassland were estimated using the 2006 IPCC GLs according to the following formula:

$$L_{life} = A \cdot M_B \cdot C_f \cdot C_{ef} \cdot 10^{-3}$$

Where:

- L_{life} - amount of GHG emissions from fire, tonnes of CH_4, N_2O, NOx and CO;
- A = area burnt, ha;
- M_B = mass of 'available' fuel, kg dry matter ha^{-1};
- C_f = combustion efficiency;
- C_{ef} = emission factor, g (kg dry matter.)$^{-1}$.

5.3.1.2.2 Activity data

The estimates of area burnt on Forest land remaining forest land is needed and there is a global database that covers annual burnt area by fires (Global forest change). However, it is good practice to develop national estimates of the area burnt and nature of the fires, because to use Tier 2 it is needed to have access to national estimates.

National Emergency Management Agency (NEMA) is a responsible body to report annual fire statistics to the NSO. The NSO's database report only fire incident statistics, but not area coverage. As a extend the data, the Fire Management Resource Center- Central Asia (FMRC-CAR) provide a detailed fire statistics for the forest and grasslands (Table 5-20).

Documentation on how many fires occur across the landscape, along with the reported number of hectares burned, varies widely across the fire entities. Only large fires are having perimeters are mapped through a time consuming satellite imagery analysis process. Furthermore, small fires that are extinguished quickly at the soum level are not being reported to NEMA. This provides challenges in not only for suppressing the fire occurrence, but also determining the true emission estimates from fires that happening on the forest and grassland landscapes, as well as determining the budget needed to support fire extinguishing efforts, especially at the soum level. Also, due to lack of human resources at the NAMEM all fires not registered at the national fire data and information registry. For example, there was unrecorded burnt area of a fire in north-western Khentii mountain range during May-June of 2009 which covered 50,000 ha. The high intensity of stand-replacing fire engulfed over 30,000 ha of old growth Siberian pine, Siberian spruce, Siberian fir, Scots pine, Siberian larch forest. This was critical example of missing large amount of carbon release from the old-growth forests.

The main limitations to fire management, specifically, fire data and information gathering and dissemination in Mongolia include institutional weaknesses, economic constraints and a lack of commitment.

Table 5-20: Activity data by the Fire management resource center - Central Asia

Year	*Burnt forest, ha*	*Burnt steppe, ha*	*Year*	*Burnt forest, ha*	*Burnt steppe, ha*	*Year*	*Burnt forest, ha*	*Burnt steppe, ha*
1986	30,600	3,156,400	1998	700,000	4,500,000	2010	58,000	244,000
1987	143,300	1,084,700	1999	25,000	5,100,000	2011	20,000	2,090,000

1988	2,300	240,700	2000	660,000	430,000	2012	300,000	4,700,000
1989	51,000	1,230,000	2001	87,000	293,000	2013	5,000	5,600,000
1990	55,000	2,522,000	2002	582,000	278,000	2014	18,000	3,100,000
1991	63,900	6,035,100	2003	320,000	3,500,000	2015	45,000	6,600,000
1992	390,700	1,123,300	2004	100,000	7,700,000	2016	138,000	2,900,000
1993	202,000	2,561,000	2005	300,000	4,053,000	2017	137,000	840,000
1994	165,000	3,435,000	2006	300,000	5,200,000	2018	43,000	42,000
1995	10,000	20,000	2007	500,000	800,000	2019	50,200	261,000
1996	2,400,000	7,800,000	2008	491,000	527,000	2020	9,500	234,000
1997	2,700,000	9,700,000	2009	161,000	244,000			

Mongolia has submitted its Forest Reference Level (FRL) to the UNFCCC in 2018. For the forest land and its change, it have used OpenForis: Collect Earth tool to produced national scale, time-series activity data (1986-2016) including fire disturbances (Table 5-21).

Table 5-21: Activity data by the Collect Earth Land Assessment Report

Year	*Burnt forest, ha*	*Year*	*Burnt forest, ha*	*Year*	*Burnt forest, ha*
1990	90,643	*2001*	153,402	*2011*	32,906
1991	10,632	*2002*	148,825	*2012*	177,676
1992	13,669	*2003*	247,541	*2013*	97,709
1993	28,350	*2004*	94,670	*2014*	19,743
1994	25,821	*2005*	90,111	*2015*	34,425
1995	20,760	*2006*	112,901	*2016**	87,589
1996	480,958	*2007*	167,092	*2017**	87,374
1997	228,362	*2008*	200,510	*2018**	67,164
1998	253,649	*2009*	206,067	*2019**	68,712
1999	88,089	*2010*	56,195	*2020**	59,962
2000	140,743				

**Values are calculated using fire statistics of FMRC-CAR with the following equation y=57,919 + 0.215 *x*
Source: CCPIU, 2017

5.3.1.2.3 Emission factors and other parameters

Estimating the mass of fuel (M_B) available for combustion comes from *"Report on Construction of Non-carbon emission estimates in Mongolia for FRL development"* (Oyunsanaa, 2017) which includes biomass, litter, and deadwood (Table 5-22). Average values for biomass are obtained from FRL (2018) report (GCP/MON/016/CBT, 2022).

Table 5-22: Combustion factor is derived from FRL report (Intact forest carbon pool C-Disturbed forest carbon pool C)

Biomass in Boreal Forest	*Intact forest plots*	*Disturbed forest plots*	*Biomass change t/ha*	*Combustion factor*
Carbon pools	B_i		ΔB_i	C_f
Above-ground	67.7	52.6	15.1	0.22
Below-ground	19.6	16	3.6	0.18
Dead wood	13.3	23.5	-10.2	-0.77
Net total			8.5	-0.36
Total (ABG+BGB+DW)	100.6	92.1	8.5	0.08

Note: The combustion factor is a measure of the proportion of the fuel that is combusted. Total biomass of intact forest estimate is used for available fuel mass for combustion.

For mass of fuel available for combustion and combustion factor were used as CS values. Emission factors and parameters used for biomass burning in forest land are presented in Table 5-23.

Table 5-23: Emission factors and parameters used for biomass burning in forest land

Emission factor and other parameters	*Gas*			*Unit*	*Sourse*
Mass of fuel available for combustion	M_B		100.6	(tonnes ha-[1])	CS
Combustion factor	C_f		0.08	(-)	CS
Emission factor for each GHG	G_{ef}	CH_4	4.7	[g GHG (kg dry matter burnt)$^{-1}$]	IPCC 2006, Vol.4, Ch.2, Table 2.5
		N_2O	0.26		
		CO	107		
		NOx	3.0		

For combustion of non-woody biomass in Grassland, CO_2 emissions do not need to be estimated and reported, because it is assumed that annual CO_2 removals (through growth) and emissions (whether by decay or fire) by biomass are in balance (see on synchrony in the 2006 IPCC GLs, Vol.2, Ch.2, Section 2.4).

For the fires in the grassland, have used default combustion factor C_f (IPCC software ver 2.18). Emission factors G_{ef} are selected as default for both forest and grassland fires (2006 IPCC GLs, Vol. 4, Ch. 2, Table 2.5). Emission factors and parameters used for biomass burning in grasslands are presented in Table 5-24.

Table 5-24: Emission factors and parameters used for biomass burning in grasslands

Emission factor and other parameters				*Unit*	*Sourse*
Mass of fuel available for combustion	M_B		2.1	(tonnes ha-[1])	2006 IPCC GLs, Vol. 4, Ch. 2, Table 2.4
Combustion factor	C_f		1	(-)	IPCC software ver 2.18
Emission factor for each GHG	G_{ef}	CH_4	2.3		2006 IPCC GLs, Vol. 4, Ch. 2, Table 2.5
		N_2O	0.21		
		CO	65		
		NOx	3.9		

5.3.1.3 Category-specific recalculations

Mongolia used the methodologies consistent with the 2006 IPCC GLs same as the iBUR. In this inventory included updated activity data and also added new category datasets and used newly developed country specific emission factors thus recalculations were done for entire time series from 1990 to 2020.

5.3.1.4 Category-specific planned improvements

To develop national estimates of the area burnt and the nature of the fires especially how they affect carbon dynamics (e.g. effects on tree mortality) to provide reliable data for the not only forest land but also for the grassland.

5.3.2 Direct N_2O emissions from managed soils (3.C.4)

5.3.2.1 Category description

In most soils, an increase in available N enhances nitrification and denitrification rates which then increase the production of N_2O. Increases in available N can occur through human-induced N additions or change of land-use and/or management practices that mineralize soil organic N.

The following N sources included for estimating direct N_2O emissions from managed soils in this report are: synthetic N fertilizers (F_{SN}); organic N applied as fertilizer (animal manure) (F_{ON}); urine and dung N deposited on pasture, range and paddock by grazing animals (F_{PRP}); and N in crop residues (F_{CR}).

The total emissions attributed to direct N_2O emissions from managed soils was 6,729.39 Gg CO_2e making up 72.24% of the total aggregate sources and non-CO_2 emission sources on land emissions in 2020. This was 125.51% higher than 1990 and 4.09% lower than 2019 levels respectively (Table 5-25). Main driver of the emission fluctuation of the direct N_2O emissions from managed soils between 1990 and 2020 is number of livestock population.

Table 5-25: Breakdown of the N_2O emissions from Direct N_2O emissions from managed soils category by source categories for the period 1990-2020, Gg N_2O

Year	*Inorganic N fertilizer application*	*Organic N applied as fertilizer (manure)*	*Urine and dung N deposited on pasture, range and paddock by grazing animals*	*N in crop residues*	*3.C.4 - Direct N_2O Emissions from managed soils*	*3.C.4 -Direct N_2O Emissions from managed soils (CO_2e)*
	N_2O (Gg)	*N_2O (Gg)*	*N_2O (Gg)*	*N_2O (Gg)*	*N_2O (Gg)*	*Gg CO_2e*
1990	0.14	0.0052	9.31	0.16	9.63	2,984.13
1991	0.16	0.0032	9.21	0.15	9.52	2,950.02
1992	0.17	0.0019	9.20	0.13	9.51	2,947.40
1993	0.01	0.0011	9.01	0.13	9.15	2,836.23
1994	0.01	0.0009	9.76	0.10	9.87	3,058.23
1995	0.03	0.0009	10.59	0.08	10.70	3,316.34
1996	0.03	0.0007	10.97	0.07	11.07	3,432.27
1997	0.08	0.0008	11.60	0.07	11.75	3,642.06
1998	0.07	0.0008	12.13	0.06	12.26	3,800.42
1999	0.04	0.0008	12.40	0.06	12.51	3,876.65
2000	0.05	0.0006	10.74	0.04	10.84	3,359.35
2001	0.05	0.0006	8.62	0.05	8.72	2,701.66
2002	0.07	0.0005	7.89	0.05	8.01	2,482.42
2003	0.06	0.0005	8.15	0.05	8.26	2,560.56
2004	0.09	0.0007	8.78	0.04	8.91	2,763.56
2005	0.06	0.0009	9.41	0.03	9.50	2,945.00
2006	0.10	0.0013	10.60	0.04	10.74	3,329.28
2007	0.09	0.0014	12.09	0.04	12.22	3,789.10
2008	0.11	0.0011	12.80	0.06	12.97	4,019.96
2009	0.12	0.0010	13.04	0.10	13.26	4,111.79
2010	0.17	0.0010	10.06	0.09	10.33	3,202.31
2011	0.22	0.0012	11.10	0.12	11.44	3,545.11
2012	0.27	0.0016	12.40	0.12	12.79	3,966.17
2013	0.40	0.0020	13.75	0.10	14.25	4,418.95
2014	0.30	0.0018	15.88	0.13	16.31	5,055.33
2015	0.33	0.0013	17.23	0.07	17.63	5,465.62
2016	0.36	0.0012	18.85	0.13	19.34	5,996.14
2017	0.56	0.0012	20.29	0.08	20.93	6,487.49
2018	0.64	0.0011	20.32	0.12	21.08	6,534.78
2019	0.73	0.0008	21.79	0.12	22.63	7,016.46
2020	0.68	0.0009	20.91	0.12	21.71	6,729.39
Diff. % 1990/2020	374.10	-81.79	124.48	-27.21	125.51	125.51
Diff. % 2019/2020	-6.57	17.42	-4.05	3.12	-4.09	-4.09

In 1990, urine and dung N deposited on pasture, range and paddock by grazing animals contributed 96.77% of the total emissions from direct N_2O. The rest were as follows: N in crop residues (1.69%), inorganic N fertilizer application (1.49%), and organic N applied as fertilizer (0.05%). By 2020, percentage share of the each source contribution to the direct N_2O emissions from managed soils was changed as follows: urine and dung N deposited on pasture, range and paddock by grazing animals (96.33%), inorganic N fertilizer application (3.12%), N in crop residues (0.54%), and organic N applied as fertilizer (0.01%). The results are shown in the Figure 5-9.

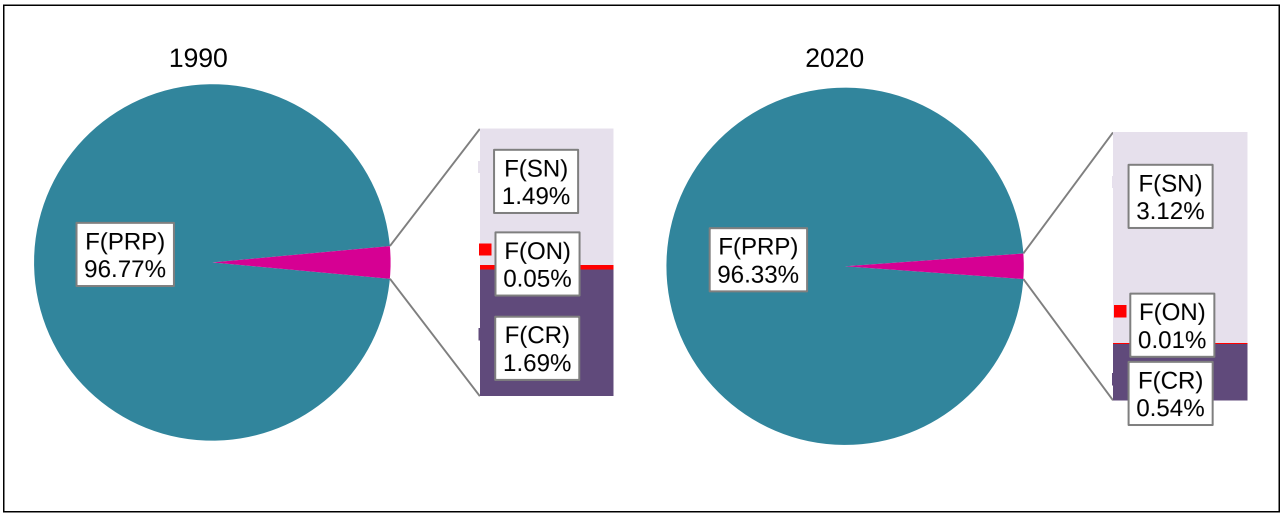

Figure 5-9: Direct N_2O emissions by source category in 1990 and 2020

5.3.2.2 Methodological issues

5.3.2.2.1 Choice of method

Emissions from direct N_2O emissions from managed soils were calculated using a Tier 1 method, following 2006 IPCC GLs Vol. 4, Ch. 10 and 11 methodologies according to the formula below:

$$N_2O_{direct} = N_2O_{(SN)} + N_2O_{(ON)} + N_2O_{(PRP)} + N_2O_{(CR)}$$

Where:

- $N_2O_{(SN)}$ – annual N_2O emissions from the amount of synthetic fertilizer N applied to soils; Gg/yr;
- $N_2O_{(ON)}$ – annual N_2O emissions from the amount of animal manure, compost, sewage sludge and other organic N additions applied to soils, Gg/yr;
- $N_2O_{(PRP)}$ – annual N_2O emissions from urine and dung inputs to grazed soils, Gg/yr;
- $N_2O_{(CR)}$ – annual N_2O emissions from the amount of N in crop residues (above-ground and below-ground), including N-fixing crops and from forages during pasture renewal, returned to soils, Gg/yr;

Inorganic N fertilizer application - $N_2O_{(SN)}$

Direct N_2O emissions from applied inorganic nitrogen fertilizers were estimated by using a Tier 1 methodology (IPCC 2006 GLs) and equation 11.2, according to the formula:

$$N_2O_{(SN)} = F_{(SN)} \cdot EF_1 \cdot 44/28$$

Where:

- $N_2O_{(SN)}$ – N_2O emissions from applied inorganic nitrogen fertilizers (Gg/yr);
- $F_{(SN)}$ – annual amount of inorganic nitrogen fertilizers applied to soils (kg N/yr);
- EF_1 – emission factor for N_2O emissions from N inputs;

- $[44/28]$ – stoichiometric ratio of nitrogen content in N_2O-N and N_2O.

Organic N applied as fertilizer (animal manure) - N_2O (ON)

Emissions from Direct N_2O emissions from the total amount of N excreted by swine was estimated using by equation 10.30 in the 2006 IPCC GLs, Vol. 4, Ch. 10 methodologies according to the formula:

$$Nex_{(T)} = N_{rate(T)} \cdot \frac{TAM}{1000} \cdot 365$$

Where:

- $Nex_{(T)}$ – annual N excretion for livestock category T, kg N animal^{-1} yr^{-1}
- $N_{rate(T)}$ – default N excretion rate, kg N (1000 kg animal mass)$^{-1}$ day^{-1}
- TAM – typical animal mass for livestock category T, kg animal^{-1}

Urine and dung N deposited on pasture, range and paddock by grazing animals - N_2O (PRP)

Nitrous oxide is produced naturally in soils through the processes of nitrification and denitrification of N inputs from urine and dung N deposited on pasture by grazing animals. Emissions from Direct N_2O emissions from urine and dung deposited by grazing animals were estimated using by equation 11.5 in the 2006 IPCC GLs, Vol. 4, Ch. 11 methodologies according to the formula:

$$F_{(PRP)} = \sum_T \left[\left(N_{(T)} \cdot Nex_{(T)} \right) \cdot MS_{(T,PRP)} \right]$$

The term $F_{(PRP)}$ refers to the annual amount of N deposited on pasture, range and paddock soils by grazing animals. $F_{(PRP)}$ is estimated using by the number of animals in each livestock species/category $T(N_{(T)})$, the annual average amount of N excreted by each livestock species/category $T(Nex_{(T)})$, and the fraction of this N deposited on pasture, range and paddock soils by each livestock species/category $T(MS_{(T,PRP)})$. Total annual amount of N deposited on pasture, range and paddock soils separately for two groups: $F_{(PRP,CPP)}$ (cattle, poultry and swine) and $F_{(PRP,SO)}$ (other livestock), according to directions of N_2O emissions estimation by the 2006 IPCC GLs.

The total amount of N excreted were estimated using by equation 10.30 in the 2006 IPCC GLs, Vol. 4, Ch. 10 methodologies by livestock categories (cattle, sheep, goats, horses, and camels) is calculated by multiplying the number of livestock heads by two coefficients: a) the Typical Animal Mass (TAM) and b) the N excretion coefficient (Nex).

N in crop residues - N_2O (CR)

During crop harvesting, a part of the crop, as agricultural residues (above-ground and below-ground), is left in the field to decompose. The nitrogen in crop residues is a relevant source for nitrification and denitrification, contributing to N_2O emissions. Annual N_2O emissions from crop residues were calculated using equation 11.6 in the 2006 IPCC GLs, Vol. 4, Ch. 11 methodologies according to the formula:

$$F_{(CR)} = \sum_T \{ [Crop_{(T)} \cdot Frac_{Renew(T)} \cdot \left(Area_{(T)} \cdot Area\ burnt_{(T)} \cdot C_f \right) \cdot R_{AG(T)} \cdot N_{AG(T)} \cdot \\ \cdot \left(1 - Frac_{Remove(T)} \right) + Area_{(T)} \cdot R_{BG(T)} \cdot N_{BG(T)}] \}$$

Where:

- $F_{(CR)}$ = 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 yr^{-1};
- $Crop_{(T)}$ = harvested annual dry matter yield for crop *T*, kg d.m. ha^{-1};
- $Area_{(T)}$ = total annual area harvested of crop *T*, ha yr^{-1};
- $Area\ burnt_{(T)}$ = annual area of crop *T* burnt, ha yr^{-1};
- C_f = combustion factor, dimensionless;
- $Frac_{Renew(T)}$= fraction of total area under crop T that is renewed annually. For countries where pastures are renewed on average every X years; $Frac_{Renew} = 1/X$. For annual crops $Frac_{Renew(T)} = 1$;
- $R_{AG(T)}$ = ratio of dry matter of above-ground residues $AG_{DM(T)}$ to harvested yield for crop $T\left(Crop_{(T)}\right)$*T* ($Crop_{(T)}$), kg d.m. (kg d.m.)$^{-1}$;
- $N_{AG(T)}$ = N content of above-ground residues for crop *T*, kg N (kg d.m.)$^{-1}$;
- $Frac_{Remove(T)}$ = fraction of above-ground residues of crop *T* removed annually for purposes such as feed, bedding and construction, kg N (kg crop-N)$^{-1}$;
- $R_{BG(T)}$ = ratio of below-ground residues to harvested yield for crop *T*, kg d.m. (kg d.m.)$^{-1}$. If alternative data are not available, $R_{BG(T)}$ may be calculated by multiplying R_{BG-BIO} by the ratio of total above-ground biomass to crop yield [($AG_{DM(T)}$ · 1000 + $Crop_{(T)}$) / $Crop_{(T)}$];
- $N_{BG(T)}$ = N content of below-ground residues for crop *T*, kg N (kg d.m.)$^{-1}$;
- T = crop or forage type.

5.3.2.2.2 Activity data

The following activity data included for calculation of direct N_2O emissions: 1. Inorganic N fertilizer application - $N_2O_{(SN)}$, 2. Organic N applied as fertilizer (animal manure) - $N_2O_{(ON)}$, 3. Urine and dung N deposited on pasture, range and paddock by grazing animals - $N_2O_{(PRP)}$, 4. N in crop residues - $N_2O_{(CR)}$.

Inorganic N fertilizer application - $N_2O_{(SN)}$

Annual amount of the synthetic fertilizer N is one of the parameters to estimate direct nitrous oxide emissions from N inputs to managed soils. N consumption data are obtained from the FAOSTAT Fertilizers Archive Dataset (1990-2001) (Inputs/ Fertilizers Archive sub domain/) and the Fertilizers Dataset (2002 to present) (Inputs/Fertilizers sub domain). These are derived as an annual balance of N production and net trade (http://www.fao.org/faostat/en/#data). In the latter dataset, the element "Nitrogen Fertilizers (N total nutrients)" corresponds to the old "Nitrogenous Fertilizers"; "Consumption in nutrients (tonnes of nutrients)" corresponds to the old "Consumption".

Organic N applied as fertilizer (animal manure) - $N_2O_{(ON)}$

The amount of N excreted by swine, treated in "daily spread" manure management systems (100%) is used for this inventory and the number of swine heads obtanied from the National Statistics Office (NSO). Both parameters are Typical Animal Mass (TAM) and N excretion coefficient (Nex) listed under Asia region are chosen for the Mongolia. Both parameters areTypical Animal Mass (TAM) and the N excretion coefficient (Nex) listed under Asia region are chosen for the Mongolia. TAM value is obtained from the 2006 IPCC GLs, Vol. 4, Ch. 10, 10A-8; Nex value is derived from the 2006 IPCC GLs, Vol. 4, Ch. 10, Table 10.19.

Urine and dung N deposited on pasture, range and paddock by grazing animals - $N_2O_{(PRP)}$

The amount of N excreted by cattle, sheep, goats, horses, and camels, treated in Pasture/Range/Paddock manure management systems (100%) used for this inventory. The number of livestock heads obtanied from the NSO. Both parameters are TAM and N excretion coefficient (Nex) listed under Asia region are chosen for the Mongolia. TAM value is obtained from the 2006 IPCC GLs, Vol. 4, Ch. 10, 10A-5 and 10A-9; Nex values are derived from the 2006 IPCC GLs, Vol. 4, Ch. 10, Table 10.19.

N in crop residues - $N_2O_{(CR)}$

Crop yield and harvested area data are used to estimate the amount of biomass N in above and below-ground residues, by crop type. The NSO compiles the statistical data of crop yield and harvested area collected from agricultural enterprises and households through agricultural surveys.

Activity data are calculated from crop yield and harvested area, and covered for wheat and potatoes because these are the most common and dominant crops in Mongolia. The crop yield and harvested area data from 1990 to 2020 are taken from NSO, website www.1212.mn.

IPCC default values have been used factors $R_{AG(T)}, N_{AG(T)}$, $R_{BG(T)}$ and $N_{BG(T)}$ which are taken from the 2006 IPCC GLs, Vol. 4, Ch.11, Table 11.2. $Frac_{Remove(T)}$ is not available in Mongolia, thus, no removal was considered. In addition, area burnt (T) is considered to be zero as no agricultural burning practices have been carried out.

Summary of activity data for $N_2O_{(SN)}$; $N_2O_{(ON)}$; $N_2O_{(CR)}$; $N_2O_{(PRP)}$ is included in Table 5-26.

Table 5-26: Activity data used for Direct and Indirect N_2O emissions from managed soils, kg N/yr

Year	F(SN): N in synthetic fertilizers	F(ON): N in animal manure, compost, sewage sludge, other	F(CR): N in crop residues	F(PRP): Amount of urine and dung N deposited on pasture, range and paddock by grazing animals
1990	9,100,000.00	330,365.18	10,379,315.92	479,994,112.13
1991	10,000,000.00	204,247.11	9,533,408.77	474,120,249.27
1992	11,000,000.00	119,098.16	8,354,777.15	473,958,277.69
1993	500,000.00	70,287.44	8,161,367.37	465,392,850.47
1994	500,000.00	57,451.93	6,214,151.92	502,049,675.85
1995	2,000,000.00	57,672.69	5,003,213.53	542,398,600.52
1996	2,000,000.00	46,811.69	4,351,961.47	560,554,016.42
1997	5,000,000.00	50,804.85	4,598,151.14	594,962,742.03
1998	4,200,000.00	48,732.23	4,020,351.74	624,377,881.93
1999	2,800,000.00	53,628.02	3,578,193.29	637,951,727.54
2000	3,400,000.00	36,016.92	2,835,076.87	560,704,477.84
2001	3,200,000.00	36,235.21	2,891,838.89	466,533,229.65
2002	4,448,000.00	32,607.52	3,000,596.94	427,511,613.27
2003	3,986,000.00	33,684.30	3,204,079.32	447,431,422.33
2004	5,873,000.00	42,139.10	2,764,580.74	485,714,600.20
2005	3,657,000.00	55,622.15	1,919,758.26	521,176,230.84
2006	6,511,000.00	80,356.18	2,509,861.84	588,505,438.61
2007	5,981,000.00	88,237.03	2,298,403.00	673,420,831.71

2008	6,921,000.00	71,830.25	3,775,092.31	715,339,092.46
2009	7,520,000.00	63,301.86	6,538,929.49	727,038,351.93
2010	11,026,000.00	60,932.46	6,015,737.08	554,119,277.40
2011	13,933,000.00	74,557.76	7,445,053.55	613,657,870.53
2012	16,935,620.00	99,144.63	7,897,653.55	686,916,874.91
2013	25,365,000.00	127,212.02	6,496,449.46	759,947,873.28
2014	19,127,430.00	113,576.90	8,024,223.44	875,339,485.14
2015	20,685,730.00	82,146.72	4,615,913.35	946,932,231.93
2016	22,963,610.00	77,236.22	8,075,785.67	1,038,207,172.82
2017	35,672,800.00	78,170.74	5,004,116.02	1,117,259,016.86
2018	40,518,820.00	68,234.44	7,540,518.09	1,119,892,830.09
2019	46,176,520.00	51,243.90	7,326,501.26	1,198,606,060.02
2020	43,143,510.00	60,169.64	7,554,781.59	1,143,311,267.99
Diff. % 1990/2020	374.10	-81.79	-27.21	138.19
Diff. % 2019/2020	-6.57	17.42	3.12	-4.61

5.3.2.2.3 Emission factors and other parameters

IPCC Tier 1 method and default N_2O emission factors were used for the estimations of emissions from managed soil. The default EF values are taken from the 2006 GLs, Vol. 4, Ch.11, Table 11.1. Summary of emission factors were used for the estimations from managed soil is presented in Table 5-27.

Table 5-27: Default emission factors to estimate direct N_2O emissions from managed soils

Emission factor		*Default value*		*Reference*
N additions from mineral fertilizers, organic amendments and crop residues, and N mineralized from mineral soil as a result of loss of soil carbon	EF_1	0.01	kg N_2O–N (kg N)$^{-1}$	IPCC 2006, Vol. 4, Ch. 11, Table 11.1
Temperate organic crop and grassland soils	EF_2 CG, Temp	8	kg N_2O–N ha^{-1}	IPCC 2006, Vol. 4, Ch. 11, Table 11.1
Cattle (dairy, non-dairy and yak), poultry and pigs	$EF_{3PRP,CPP}$	0.02	kg N_2O–N (kg N)$^{-1}$	IPCC 2006, Vol. 4, Ch. 11, Table 11.1
Sheep and 'other animals'	$EF_{3PRP,SO}$	0.01	kg N_2O–N (kg N)$^{-1}$	IPCC 2006, Vol. 4, Ch. 11, Table 11.1

5.3.2.2.4 Source specific uncertainties and time series consistency

Uncertainty in the Direct N_2O emissions from managed soils arises from uncertainties of activity data and emission factors. The 2006 IPCC GLs recommended default values were used as the source of uncertainty values. However, expert judgment was performed for selecting the values applicable for GHG emission calculations from this subcategory which are presented in Table 5-28. The uncertainty of activity data for yield and cultivated area obtained from NSO was considered to be 10%, and for fertilizer data obtained from FAOSTAT to be 40%. The time series was checked for the consistency.

Table 5-28: Estimated values of uncertainties used in Direct N_2O emissions from managed soils

Emission factor	*Uncertainties*	*Uncertainty range*	*Reference*
EF_1	0.01	0.003 - 0.03	IPCC 2006, Vol. 4, Ch. 11, Table 11.1
EF_2 CG, Temp	8	2 - 24	
$EF_{3PRP,CPP}$	0.02	0.007 - 0.06	
$EF_{3PRP,SO}$	0.01	0.003 - 0.03	

5.3.2.3 Category-specific recalculations

Recalculations were done due to slight changes in the entire time series of $F_{(CR)}$ in calculations and acitivty data.

5.3.2.4 Category-specific planned improvements

There are planned activities that will improve the data quality for this category.

5.3.3 Indirect N_2O emissions from managed soils (3.C.5)

5.3.3.1 Category description

In addition to the direct emissions of N_2O from managed soils that occur through a direct pathway (i.e., directly from the soils to which N is applied), emissions of N_2O also take place through two indirect pathways. The first one of these pathways is the volatilization of N as NH_3 and oxides of N (NO_x), and the deposition of these gases and their products NH^{4+} and NO^{3-} onto soils and the surface of lakes and other waters. The second pathway is the leaching and runoff from land of N from synthetic and organic fertilizer additions, crop residues, mineralization of N associated with loss of soil C in mineral and drained/managed organic soils through land-use change or management practices, and urine and dung deposition from grazing animals.

The following N sources included for estimating indirect N_2O emissions from managed soils in this report are: synthetic N fertilizers $F_{(SN)}$; organic N applied as fertilizer (animal manure) $F_{(ON)}$; urine and dung N deposited on pasture, range and paddock by grazing animals $F_{(PRP)}$; and N in crop residues $F_{(CR)}$ and results are summarized as volatilization and leaching/runoff pathways in the Table 5-29.

The total emissions attributed to indirect N_2O emissions from managed soils was 2,443.77 Gg CO_2e contributing 10.91% of the total aggregate sources and non-CO_2 emission sources on land emissions in 2020. This was 139.53% higher than 1990 and 4.64% lower than 2019 levels respectively.

Table 5-29: Breakdown of the N_2O emissions from Indirect N_2O emissions from managed soils category by emission pathway for the period 1990-2020, Gg

Year	*Volatilization pathway* *Gg N_2O*	*Leaching/runoff pathway* *Gg N_2O*	*3.C.5 - Indirect N2O emissions from managed soils* *Gg N_2O*	*3.C.5 - Indirect N_2O emissions from managed soils* *Gg CO_2e*
1990	1.524	1.767	3.291	1,020.23
1991	1.506	1.746	3.253	1,008.30
1992	1.507	1.745	3.252	1,008.08
1993	1.464	1.676	3.14	973.41
1994	1.579	1.799	3.378	1,047.14
1995	1.708	1.943	3.651	1,131.73

1996	1.765	2.005	3.77	1,168.58
1997	1.878	2.138	4.016	1,244.85
1998	1.969	2.237	4.206	1,303.84
1999	2.01	2.278	4.288	1,329.25
2000	1.768	2.005	3.772	1,169.42
2001	1.471	1.671	3.143	974.2
2002	1.351	1.538	2.889	895.5
2003	1.413	1.608	3.02	936.24
2004	1.536	1.748	3.284	1,018.02
2005	1.644	1.863	3.507	1,087.03
2006	1.86	2.113	3.973	1,231.64
2007	2.126	2.411	4.537	1,406.39
2008	2.259	2.567	4.827	1,496.25
2009	2.297	2.621	4.918	1,524.43
2010	1.759	2.02	3.779	1,171.40
2011	1.951	2.246	4.196	1,300.86
2012	2.186	2.517	4.703	1,457.84
2013	2.429	2.8	5.229	1,620.91
2014	2.781	3.191	5.973	1,851.58
2015	3.009	3.438	6.447	1,998.47
2016	3.299	3.781	7.08	2,194.83
2017	3.568	4.094	7.662	2,375.25
2018	3.584	4.13	7.713	2,391.13
2019	3.84	4.427	8.267	2,562.79
2020	3.661	4.222	7.883	2,443.77
Diff. % 1990/2020	140.26	138.91	139.53	139.53
Diff. % 2019/2020	-4.65	-4.64	-4.64	-4.64

In 1990 and 2020, share percentage between volatilization and leaching/runoff pathways are 46-47% and 53-54% respectively. The total indirect N_2O emissions from agricultural soils by two pathways are shown in Figure 5-10.

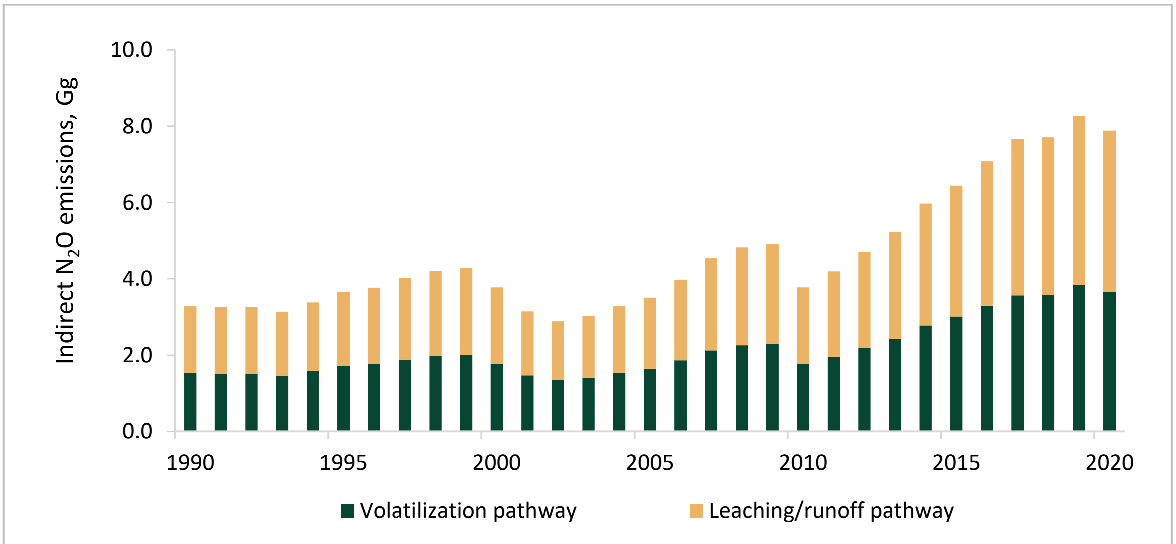

Figure 5-10: Indirect N_2O emissions from managed soil

5.3.3.2 Methodological issues

5.3.3.2.1 Choice of method

This section provides estimation methods for N_2O indirect emissions caused by atmospheric deposition of nitrogen compounds through volatilizing as NH_3 and NOx from synthetic fertilizers applied to soil, organic fertilizers applied to soil, and the grazing livestock manure applied to soil.

Emissions from indirect N_2O emissions from managed soils were calculated using Tier 1 method of the 2006 IPCC GLs, Vol. 4, Ch. 10 and 11 methodologies according to the formula:

$$N_2O_{indirect} = N_2O_{(ATD)} + N_2O_{(L)}$$

Where:

- $N_2O_{(ATD)}$ – indirect N_2O emissions, produced from atmospheric deposition of nitrogen as ammonia (NH_3), oxides of N (NO_x), and their products NH^{4+} and NH^{3-} onto soils and the surface of lakes and other waters; deposition of agriculturally derived NH_3 and NO_x, following the application of synthetic and organic N fertilizers and/or urine and dung deposition from grazing animals;
- $N_2O_{(L)}$ – from leaching and runoff from land of N from synthetic and organic fertilizer additions, crop residues returned to soils, mineralization of N associated with loss of soil C in mineral and drained/managed organic soils through land-use change or management practices and urine and dung deposition from grazing animals.

Volatilisation, $N_2O_{(ATD)}$

The N_2O emissions from atmospheric deposition of N volatilised from managed soil are estimated using equation 11.9 in the 2006 IPCC GLs, Vol. 4, Ch. 11 methodologies according to the formula:

$$N_2O_{(ATD)} - N = \left[\left(F_{(SN)} \cdot\ Frac_{GASF}\right) + \left(\left(F_{(ON)} + F_{(PRP)}\right) \cdot\ Frac_{GASM}\right)\right] \cdot EF_4$$

Where:

- $N_2O_{(ATD)} - N$ − annual amount of N_2O–N produced from atmospheric deposition of N volatilized from managed soils, kg N_2O–N yr^{-1}
- $F_{(SN)}$ − annual amount of synthetic fertiliser N applied to soils, kg N yr^{-1}
- $Frac_{GASF}$ − fraction of synthetic fertiliser N that volatilises as NH_3 and NOx, kg N volatilised (kg of N applied)$^{-1}$
- $F_{(ON)}$ − annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1}
- $F_{(PRP)}$ − annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1}
- $Frac_{GASM}$ − fraction of applied organic N fertiliser materials $F_{(ON)}$ and of urine and dung N deposited by grazing animals $F_{(PRP)}$ that volatilises as NH_3 and NOx, kg N volatilised (kg of N applied or deposited)$^{-1}$
- EF_4 − emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, [kg N–N_2O (kg NH_3–N + NOx–N volatilised)$^{-1}$]

Conversion of ($N_2O_{(ATD)} - N$) emissions to N_2O emissions for reporting purposes is performed by multiplying 44/28.

Leaching/Runoff, $N_2O_{(L)}$

The N_2O emissions from leaching and runoff estimated using equation 11.10 in the 2006 IPCC GLs, Vol. 4, Ch. 11 methodologies according to the formula:

$$N_2O_{(L)} - N = \left(F_{(SN)} + F_{(ON)} + F_{(PRP)} + F_{(CR)} + F_{(SOM)}\right) \cdot Frac_{LEACH-(H)} \cdot EF_5$$

Where:

- $N_2O_{(L)} - N$ − annual amount of N_2O–N produced from leaching and runoff of N additions to managed soils in regions where leaching/runoff occurs, kg N_2O–N yr^{-1}
- $F_{(SN)}$ − annual amount of synthetic fertiliser N applied to soils, kg N yr^{-1}
- $F_{(ON)}$ − 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 yr^{-1}
- $F_{(PRP)}$ − annual amount of urine and dung N deposited by grazing animals in regions where leaching/runoff occurs, kg N yr^{-1}
- $F_{(CR)}$ − 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 yr^{-1}
- $F_{(SOM)}$ − 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 yr^{-1}
- $Frac_{LEACH-(H)}$ − 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 of N additions)$^{-1}$
- EF_5 – emission factor for N_2O emissions from N leaching and runoff, kg N_2O–N (kg N leached and runoff)$^{-1}$

Conversion of ($N_2O_{(L)} - N$) emissions to N_2O emissions for reporting purposes is performed by multiplying 44/28.

5.3.3.2.2 Activity data

Atmospheric deposition

The estimation of N_2O emissions from Atmospheric deposition was carried out based on activity data (synthetic fertilizers, organic amendments applied to soils, urine and dung deposited by grazing animals).

Nitrogen leaching and run-off

The estimation of N_2O emissions from Nitrogen leaching was carried out based on activity data (synthetic fertilizers, organic amendments applied to soils, urine and dung deposited by grazing animals and crop residues).

In order to estimate indirect N_2O emissions from the various N additions to managed soils, the parameters $F_{(SN)}$; $F_{(ON)}$; $F_{(PRP)}$; $F_{(CR)}$; $F_{(SOM)}$ are required. The data sources are same as direct N_2O emissions from managed soils, for details see 5.3.2.2.2.

5.3.3.2.3 Emission factors and other parameters

Atmospheric deposition

The IPCC default emission factor of 0.01 kg N_2O-N/(kg NH_3-N+NO_X-N volatilized) obtained from the 2006 IPCC GLs is used to calculate indirect emissions of N_2O from volatilized NH_3 and NO_X.

Nitrogen leaching and run-off

The IPCC default emission factor of 0.0075 kg N_2O-N/kg N obtained from the 2006 IPCC GLs is used to calculate indirect emissions of N_2O from leaching/runoff.

The emission factors and fractions applied to estimate the Volatilisation ($N_2O_{(ATD)}$) and Leaching/Runoff ($N_2O_{(L)}$) to include above formula is presented in Table 5-30.

Table 5-30: Summary of emission factor and fractions used for Indirect N_2O emissions from managed soils

Emission factor and fractions		*Default value*		*Reference*
N volatilization and re-deposition	EF_4	0.01	kg N_2O–N (kg NH_3–N + NOx–N volatilized)$^{-1}$	2006 IPCC GLs, Vol. 4, Ch.11, Table 11.3
Leaching/run-off	EF_5	0.0075	kg N_2O–N (kg N leaching/run-off)	2006 IPCC GLs, Vol. 4, Ch.11, Table 11.3
Volatilization from all organic N fertilizers applied, and dung and urine deposited by grazing animals	$Frac_{GASM}$	0.2	(kg NH_3–N + NOx–N) (kg N applied or deposited) $^{-1}$	2006 IPCC GLs, Vol. 4, Ch.11, Table 11.3
Volatilization from synthetic fertilizers	$Frac_{GASF}$	0.1	(kg NH_3–N + NOx–N) (kg N applied) $^{-1}$	2006 IPCC GLs, Vol. 4, Ch.11, Table 11.3
N losses by leaching/run-off	$Frac_{LEACH(H)}$	0.3	kg N (kg N additions or deposition by grazing animals)$^{-1}$	2006 IPCC GLs, Vol. 4, Ch.11, Table 11.3

5.3.3.2.4 Source specific uncertainties and time series consistency

Atmospheric deposition

The estimation of N_2O emissions from the Atmospheric deposition was carried out based on activity data (synthetic fertilizers, organic amendments applied to soils, and urine and dung deposited by grazing animals) and emission factors.

The Nitrogen (N_2O) emission factor was used from the 2006 IPCC GLs and its value is 0.01 within a range of 0.002–0.05.

Nitrogen leaching and run-off

The estimation of N_2O emissions from Nitrogen leaching was carried out based on activity data (synthetic fertilizers, organic amendments applied to soils, urine and dung deposited by grazing animals and crop residues) and emission factors (fraction of the synthetic fertilizers, organic amendments applied to soils, urine and dung deposited by grazing animals, crop residues, nitrogen lost to leaching and surface run-off, and N_2O emission factor).

N_2O emission factor is reported from the 2006 IPCC GLs and its value is 0.0075 within a range of 0.0005–0.025.

Uncertainty of the Indirect N_2O emissions from managed soils arises from uncertainties in activity data and emission factors. The 2006 IPCC GLs recommended default values are used as the source of uncertainty values. However, expert judgment was performed to choose values applicable for GHG emission calculations from this subcategory, which are presented in Table 5-31. The time series was checked for the consistency.

Table 5-31: Estimated values of uncertainties used in the Indirect N_2O emissions from managed soils

Emission factor and fractions	*Uncertainties*	*Uncertainty range*	*Reference*
EF_4	0.01	0.002 - 0.05	
EF_5	0.0075	0.0005 - 0.025	IPCC 2006, Vol. 4, Ch.11, Table 11.3
$Frac_{GASM}$	0.20	0.03 - 0.3	
$Frac_{GASF}$	0.10	0.05 - 0.5	
$Frac_{LEACH(H)}$	0.30	0.1 - 0.8	

5.3.3.3 Category-specific recalculations

Recalculations were done due to slight changes in the entire time series of $F_{(CR)}$ in calculations and acitivty data.

5.3.3.4 Category-specific planned improvements

There are planned activities that will improve the data quality for this category.

CHAPTER 6: LAND USE, LAND USE CHANGE AND FORESTRY

6.1 Overview of sector

Table 6-1 summarizes GHG emissions and removals from the Land Use, Land Use Change and Forestry (LULUCF) sector of Mongolia from 1990 to 2020. In 2020, total removals were -30,172.52 Gg CO_2e which was increased by 3.95% compared with 1990 level of -29,027.19 Gg CO_2e, mainly occurred in forest land category.

Table 6-1: GHG emissions and removals from LULUCF sector by source categories, Gg CO_2e

Subcategory	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*Diff, Gg CO_2e 1990/2020*	*Diff, %*
3.B.1 – Forest land	-29,367.35	-31,124.02	-29,432.74	-30,171.68	-30,598.34	-30,897.70	-30,336.91	-969.56	3.30
3.B.3 – Land converted to Grassland	422.86	6.92	1,588.08	10.38	8.75	9.32	4.89	-417.97	-98.84
3.B.6 – Land converted to Other land	NO	NO	367.18	141.55	56.13	NO	NO	-	-
3.D.1 – Harvested wood products	-82.70	296.46	338.11	335.52	268.21	197.13	159.5	242.20	-292.87
3 – LULUCF total	-29,027.19	-30,820.64	-27,139.37	-29,684.24	-30,265.24	-30,691.25	-30,172.52	-1,145.33	3.95

NE – Emissions occur but have not been estimated and/or reported

A long-term trend of the sectoral GHG emissions and removals is presented in Figure 6-1. GHG emissions and removals from HWP and land use change in all land subcategories were less than 1% and 5%, respectively, of the sectoral total during entire time series.

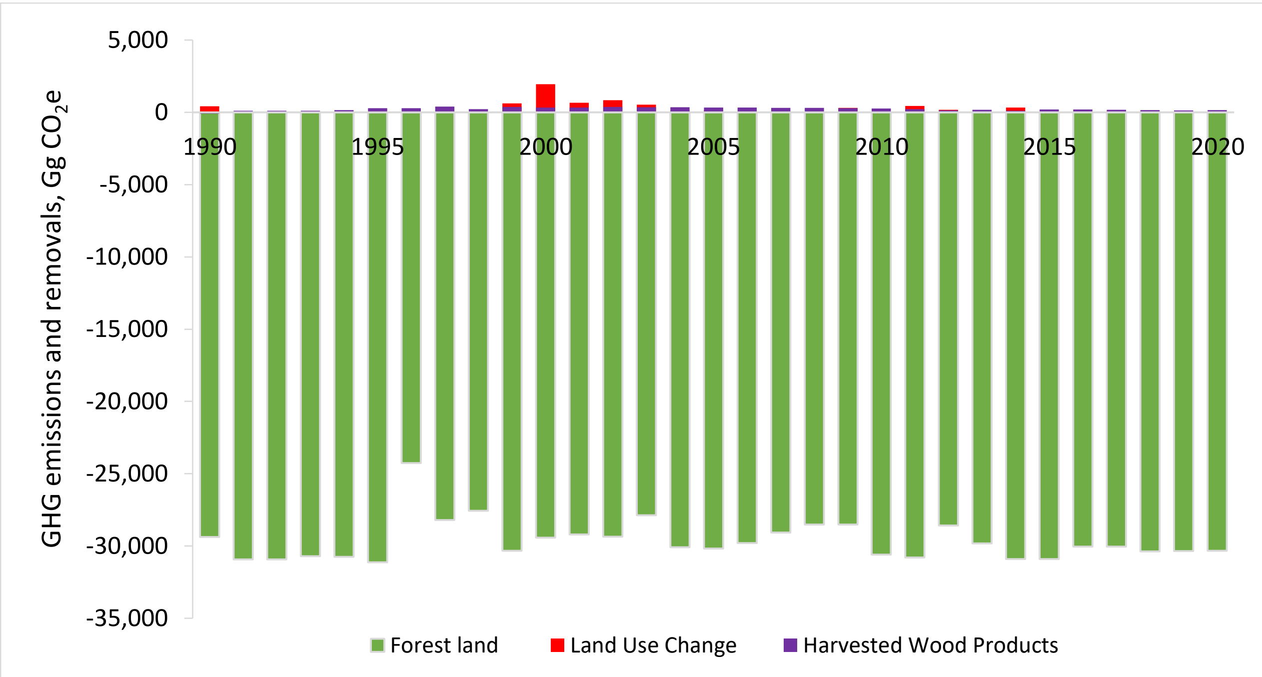

Figure 6-1: GHG emissions and removals from LULUCF sector by source categories, Gg CO_2e

In Figure 6-2 shown long-term trends of subsectoral GHG emissions and removals estimated and included in the total emissions and removals from the LULUCF sector of Mongolia. In Figure 6-1 (a) shows the net emissions and removals of land category and it was a sink of -30,336.91 GgCO_2 in 2020 (Table 6-1).

The long-term trend of emissions and removals in the LULUCF sector was mainly driven by CO_2 removals from forest land (Figure 6-2 (b and c)) category with main decline driven by emissions from land converted to grassland (Figure 6-2 (d)) and land to other land (Figure 6-2 (e)); and harvested wood products (Figure 6-2 (f)), especially, in 1996, 1997, 2000, 2011 and 2012. Indeed, in 1996 and 1997, it has been observed a largest fire on forest land, and also, harvested wood products were the highest since 1990.

The forest land category comprises emissions and removals from the forest land remaining forest land (Figure 6-2 (b)) and the land converted to forest land (Figure 6-2 (c)). Forest land remaining forest land includes removals from the boreal and Saxaul forests which is one of the key categories of GHG inventory of Mongolia. Land converted to forest land subcategory includes conversion of grassland, cropland, settlements and wetlands to forest land. The forest land category is estimated to total removal of -30,336.91 Gg CO_2e in 2020 compared with 1990 level of -29,367.35 Gg CO_2e, an increase in GHG removals by 3.30% (Table 6-1). Changes in GHG emissions and removals occur mainly due to forest regeneration or/and annual harvest. For example, about 1.0 million hectares of forests that were affected by the great fires of the 1990s and early 2000s are started regrowing naturally (MET, 2019b).

GHG emissions from HWP was 159.50 Gg CO_2e in 2020 that was 292.87% increase compared with 1990 level of -82.7 Gg CO_2e which was only year when GHG removals occurred from HWP (Table 6-1). As shown in Figure 6-2 (f), in 1996 and 1997 GHG emissions and removals from the HWP category were the highest since 1990, then decreased until early 2010, and then stayed in the same level until 2020. Because in 2012 the Law on Forestry was approved by the Mongolian government and the Minister of Environment and Tourism has set the maximum limit of trees to be harvested and used from the forest in a given year, for example, it was 1437.90 thousand m^3 in 2020. Actual amount of harvested wood was 776.5 thousand m^3 in 2020 to meet consumptions of lumber, out of which 22.5% for domestic production and 77.5% for fuelwood.

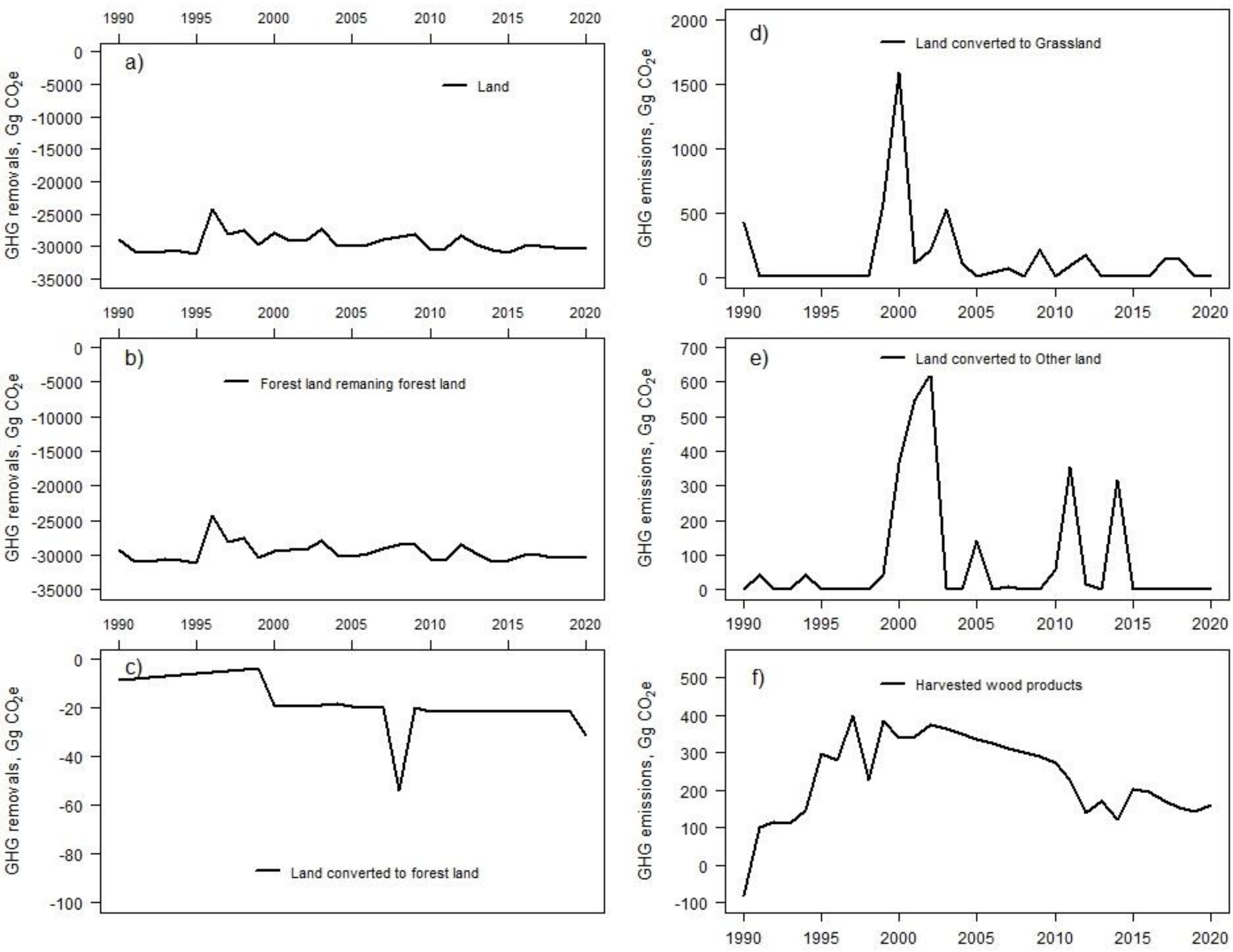

Figure 6-2: Long term trends of subsectoral GHG emissions and removals from LULUCF sector, Gg CO_2e

6.1.1 Methodological issues

The 2006 IPCC guidelines for national greenhouse gas inventories (the 2006 IPCC GLs) for the AFOLU sector and the Good practice guidance (GPG) for LULUCF were used to estimate GHG emissions and removals. A country specific land matrix obtained from the Agency for land administration and management, geodesy, and cartography (ALAMGAC, 2021) using the Collect earth program was used for GHG inventory of LULUCF. Land matrix includes six land use categories such as forest land, cropland, grassland, wetlands, settlements and other land, and land area conversions among land subcategories. However, due to lack of the activity data (grassland, cropland, and wetlands subcategories) and country specific method for calculations (settlements, and other land) emissions and removals from these subcategories were not reported in this iteration of national GHG inventory. Thus, this report included GHG emissions and removals from the forest land remaining forest land, and emissions from land conversions among different types of land management into another land types, and the harvested wood products.

Mongolia is required country specific emission factors and other parameters, especially, the SOCref and the methodology how to address the changes occurred in Mongolian grassland in different climate zones. Where country specific activity data is not available, expert's assumptions were applied. For example, to costract a 20-year-cumulative land matrix in the land category was used expert judgement; and also, reconstructing sawnwood data for missing inventory years was applied expert's judgement.

A summary description of methods used to estimate emissions by subcategories is provided in Table 6-2. GHG emissions and removals were estimated considering both Tier 1 and Tier 2 methods, including country specific activity and FAOSTAT database; and country specific and the IPCC default emission factors.

Table 6-2: Summary methods used to estimate GHG emissions for the LULUCF sector

IPCC code	*Source categories*	*CO_2*	
		Method	*EF*
3.B.1	Forest land	T1, T2	CS/D
*3.B.2**	Cropland	NE	NE
*3.B.3**	Grassland	T1	D
*3.B.4**	Wetlands	NE	NE
*3.B.5**	Settlements	NE	NE
*3.B.6**	Other land	T1	D
3.D.1	Harvested wood products	T1	CS

*Note: CS -– country specific; D – default; T1 – IPCC Tier 1 method; T2 – IPCC Tier 2 method, *-only emissions from conversions among different types of land management into another land types (i.e. land use change).*

6.1.2 Key categories

The results of key category analysis (including LULUCF) are shown in Table 6-3. The removal from forest land remaining forest land was included in both level and trend assessments as a key source category and land converted to grassland subcategory was a key category in trend assessment.

Table 6-3: Key category analysis under the LULUCF sector

IPCC code	*Source categories*	*GHG*	*Key categories*
3.B.1.a	Forest land remaining forest land	CO_2	Yes (L, T)
3.B.3.b	Land Converted to Grassland	CO_2	Yes (T)

Note: L- level assessment, T- trend assessment

6.1.3 Uncertainty assessment and time series consistency

Land area matrix obtained from ALAMGAC using the Collect earth program is applied for estimating emissions and removals from LULUCF sector. The "*Guidelines for converting the unified land territory classification of Mongolia to the international land use classification"* updated and approved by ALAMGAC in 2022. Applying the guideline into GHG inventory ensures to reduce uncertainties related to the land classification not to be a subject for further changes and is important for data consistency.

No land use information was available for the years prior to 1986, thus, reconstructing the 20-year cumulative land activity data requires accurate assumptions based on the historical data information such as UNFAO FAOSTAT or national statistics and professional experts' expertise. For example, uncertainty may raise due to this assumption when land use change was observed only once or twice for the period 1986-2020, then this types of land use change was assumed to be happened by unexpected reasons and assumed that no land use change was occurred in the relevant land use change during 1971-1985. Uncertainty assessment of this sector for base year (1990), and last inventory year (2020) is described in ANNEX III of this report.

6.1.4 Quality assurance and Quality control (QA/QC)

In the current submission, all applied information and data sources have been double checked for accuracy of information, confidentiality of sources, calculations, applications of correctness and completeness. The application of methods have been proof-read and follows the 2006 IPCC GLs. The activity data and methods used to estimate GHG emissions under this sector was documented and archived both in hard and electronic copies.

6.1.5 Source specific recalculations

Recalculation was conducted for forest land remaining forest land and HWP categories with country specific updated emission factors and incorporating the most recent data for entire time series from 1990 to 2020. Thus, compared to earlier version of the Mongolian GHG inventory (iBUR), the entire inventory considered as a recalculated. In Table 6-4 shows the comparisons of GHG emissions and removals of LULUCF sector for iBUR and BUR2 from 1990 to 2014.

Table 6-4: Comparison of initial BUR (iBUR) and recalculated second BUR (BUR2) of GHG emissions from LULUCF, Gg CO_2e

Year	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
iBUR	-23,024.18	-22,950.70	-22,992.04	-23,099.45	-23,212.78	-23,364.15	-23,596.88	-23,762.22	-24,407.44
BUR2	-29,027.19	-30,777.08	-30,796.13	-30,583.27	-30,565.82	-30,820.64	-23,973.92	-27,806.97	-27,328.36
Diff. %	26.07	34.10	33.94	32.40	31.68	31.91	1.60	17.02	11.97
Year	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
iBUR	-25,328.82	-25,188.38	-25,828.96	-25,884.36	-25,547.44	-25,639.68	-25,358.09	-24,750.19	-24,757.59
BUR2	-29,321.59	--27,139.37	-28,193.79	-28,132.70	-26,968.87	-29,624.81	-29,684.24	-29,450.74	-28,676.81
Diff. %	15.76	7.75	9.16	8.69	5.56	15.54	17.06	18.99	15.83
Year	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*		
iBUR	-24,716.09	-24,950.95	-24,670.87	-24,636.33	-24,377.05	-24,547.66	-24,451.93		
BUR2	-28,205.77	-27,917.77	-30,265.24	-30,115.90	-28,257.61	-29,648.23	-30,466.11		
Diff. %	14.12	11.89	22.68	22.24	15.82	20.78	24.60		

6.1.6 Assessment of completeness

Current LULUCF inventory covers CO_2 emissions and removals from two source categories: land (3.B) and other (3.D) from 1990 to 2020. Table 6-5 shows the overview of the completeness status of estimations under various source categories within the sector. Categories included in the inventory consists of land category that includes forest land remaining forest land (3.B.1.a) and land converted to grassland (3.B.3.b); and other harvested wood products (3.D.1). Other subcategories are not included due to lack of activity data and methodology.

As demonstrated in Table 6-5, in Forest remaining forest sector, the CO_2 removals estimated (E) from biomass growth, however, since Tier 1 method was applied, CO_2 emissions from dead organic matter and soil carbon pools are not applicable (NA). In this iteration of the inventory, CH_4 and N_2O and others gases emissions from forest and grassland fires are reported in the Chapter 5 (Agriculture sector's total emissions), thus, it is reported as included elsewhere (IE) and emissions from drained organic soils is not estimated (NE). Also, forest and grassland fires occurs in the forest land and grassland, however, there is no activity data available for separating how much those converted land was affected (NE). In Grassland remaining grassland category the Tier 1 method was applied, thus, no carbon stock change in pools for biomass and dead organic matter (NA) and soil organic carbon is not estimated (NE). Also, Savannah burning is does not happening and non-CO_2 emissions reported as not occuring (NO). In Land converted to grassland category, forest land converted to grassland subcategory have been estimated (E), but no default values available for dead wood and litter (NA) for this category. The CO_2 emissions from Harvested wood products is estimated (E).

Table 6-5: Assessment of completeness for GHG emissions and removals for LULUCF sector

IPCC category	*Source categories*	*Status of gas*		
		CO_2	*CH_4*	*N_2O*
3.B.1 – Forest land	3.B.1.a – Forest land remaining forest land	E, NA	IE, NE	IE, NE
	3.B.1.b.i – Cropland converted forest land	NE	IE, NE	IE, NE
	3.B.1.b.ii – Grassland converted forest land	E, NA	IE, NE	IE, NE
	3.B.1.b.iii – Wetlands converted forest land	NE	IE, NE	IE, NE
	3.B.1.b.iv – Settlements converted forest land	NE	IE, NE	IE, NE
	3.B.1.b.v – Other land converted forest land	NE	IE, NE	IE, NE
3.B.2 - Cropland	3.B.2.a – Cropland remaining cropland	NE	NE	NE
	3.B.2.b.i – Forest land converted cropland	NE	NE	NE
	3.B.2.b.ii – Grassland converted cropland	NE	NE	NE
	3.B.2.b.iii – Wetlands converted cropland	NE	NE	NE
	3.B.2.b.iv – Settlements converted cropland	NE	NE	NE
	3.B.2.b.v – Other land converted cropland	NE	NE	NE
3.B.3 - Grassland	3.B.3.a – Grassland remaining grassland	NE, NA	IE, NO	IE, NO
	3.B.3.b.i – Forest land converted grassland	E, NA	IE, NO	IE, NO
	3.B.3.b.ii – Cropland converted grassland	NE	IE, NO	IE, NO
	3.B.3.b.iii – Wetlands converted grassland	NE	IE, NO	IE, NO
	3.B.3.b.iv – Settlements converted grassland	NE	IE, NO	IE, NO
	3.B.3.b.v – Other land converted grassland	NE	IE, NO	IE, NO
3.B.4 - Wetlands	3.B.4.a – Wetlands remaining wetlands	NE	-	NE
	3.B.4.a – Wetlands remaining wetlands	NE	-	-
	3.B.4.b.i – Forest land converted wetlands	NE	-	-
	3.B.4.b.ii – Cropland converted wetlands	NE	-	-
	3.B.4.b.iii – Grassland converted wetlands	NE	-	-
	3.B.4.b.iv – Settlements converted wetlands	NE	-	-
	3.B.4.b.v – Other land converted wetlands	NE	-	-
3.B.5 - Settlements	3.B.5.a – Settlements remaining settlements	NA	-	-
	3.B.5.b.i – Forest land converted settlements	NE	-	-
	3.B.5.b.ii – Cropland converted settlements	NE	-	-
	3.B.5.b.iii – Grassland converted settlements	NE	-	-
	3.B.5.b.iv – Wetlands converted settlements	NE	-	-
	3.B.5.b.v – Other land converted settlements	NE	-	-
3.B.6 – Other land	3.B.6.a – Other land remaining other land	-	-	-
	3.B.6.b.i – Forest land converted other land	NE	-	-
	3.B.6.b.ii – Cropland converted other land	NE	-	-
	3.B.6.b.iii – Grassland converted other land	NE	-	-
	3.B.6.b.iv – Wetlands converted other land	NE	-	-
	3.B.6.b.v – Settlements converted other land	NE	-	-
3.D - Other	3.D.1 – Harvested wood products	E	-	-

Abbreviations: E -Estimated, source categories included in the inventory; NO - Not Occurring; NE - Not Estimated, NA – Not Applicable

6.1.7 Source specific planned improvements

The six main land categories of the CE assessment align with the IPCC land categories. But this report covered only the forest land remaining forest land, land converted to forest land, land converted to grassland and HWP subcategories for the LULUCF sector. The emissions from the rest of the subcategories were not included because it was not estimated due to lack of activity data (grassland cropland, and wetlands) and country specific methods (i.e. settlements and other land). Thus, total emissions and removals from this sector may be overestimated or underestimated and further improvements needed to address in next iteration of national inventory as follows in prioritized order:

- Carbon stock changes and relevant GHG gases emissions from grassland in Mongolia have not estimated in the past GHG inventories. This means net emissions and removals occurred in huge area of Mongolia remains unknown. Address this not-estimated source/removals is one of the top priority issues of the LULUCF sector. For next inventory cycle, a new activity database needed for grassland remaining grassland and land converted to grassland, and also same time to transfer GHG estimation in to Tier 2 or higher level for grassland subcategory. Database needed the grassland degradation levels by climate and geographical regions.
- Perform the ground-truth validation for CE data for selected years and choose the most reliable grassland data source for GHG emissions from LULUCF sector.
- Develop an accurate method to calculate the 20-year cumulative land area matrix for six land categories and related land conversions from one to another.
- There is lacking a real time accurate data for Saxaul forest area and its annual changes. It is important to have an unified database within same year conducted with same methodology and to develop tree species specific parameters to improve the GHG emission estimation.
- In cropland category, improvement is required to obtain accurate activity data that separates both perennial and crop plants.

6.2 Land use definitions and classification systems applied to LULUCF sector

6.2.1 Category description

Since 1958 Mongolia has implemented a Taxation forest inventory (TFI) which was designed for forest management and planning purposes. The TFI defined a threshold value of relative stock density to be at least 0.3 per hectare to qualify as a forest. Results from TFI were submitted to the UNFAO forest resources assessments (FRA).

In 2014, the first national forest inventory (NFI) was initiated and in-field data collection has been made over time period of 2014-2017 based on a forest definition designed to fit in Mongolian boreal forest. For consistency, the forest reference level (FRL), Mongolia, applied the same definition for a forest as of NFI (2019). Compared to the FRA definition, there are a few thresholds were modified such as: 1) a minimum height of tree was reduced from '5 m' to '2 m'; and 2) a minimum area of forest cover was modified from '0.5 ha' to '1 ha'. These revisions were made to include some common tree species such as birch (*Betula exilis, B. Humilis*) and dwarf pine (*Pinus pumila*), those do not reach 5 m in overall height in this climate.

The definition of 'a forest' for Mongolia's boreal forest can be summarized and will be used in the future forest monitoring as follows: "*all lands where trees 2 m or more in height and cover at least 10% per hectare*". This definition will be used in future national and international communications. A definition for 'a Saxaul' forest was adopted from scientific publication of Jalbaa and Enkhsaikhan (1991) where "*regular minimum height the Saxaul is 1 m and its minimum crown cover of 4.65% per hectare*". This was consistent with the FRL study report (2018), where a 4% per ha area threshold was used to define the Saxaul forest.

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

6.3.1 The Integrated land fund - ALAMGAC

A new database established in purpose of improving the LULUCF data quality during the "*National land use and land use change assessment*" project completed in 2020 using the "Collect earth (CE)" program from the Integrated land fund (ILF) data prepared by the ALAMGAC. The ALAMGAC digital data on topographic maps at a scale of 1:100 000 which consists of 132 basic layers, considering information contained in the main layers and sublayers of the topographic map database, the 36 main layers are coordinated into the IPCC classification methodology (ALAMGAC, 2019). Mongolia has a total of 156,411,754.66 ha territory out of which 156,006,444.00 ha land area was included in GHG inventory. Total 65 layers that did not meet the IPCC classification and did not have attributed information were identified and removed from the database, totaling 405,130.66 ha (0.26% of country's total area).

The land use matrix of LULUCF (in hectare) by the IPCC land use categories from 1986 to 2020 was developed by converting land types from the Integrated land territory (ILT, t=1) by ALAMGAC into the IPCC land classifications. The results are presented in Annex IV and it was applied for the national GHG inventory (ALAMGAC, 2021).

6.3.2 Activity data for IPCC land conversion matrix (20 year-cumulative)

The side-scrolling time series of a 20 years-cumulative land area matrix during 1986-2019 (t=20) were calculated based on the annual land area matrix (t=1, ANNEX IV) to estimate gradual gains or losses occurred from the year of land conversion to another land. Activity data for the years 1971-1986 was estimated based on the expert's assumption. Here, main assumption is "*if during 34 years from 1986 to 2020 the land conversion of the same type happened more than two occurrences then this same change might have happened gradually from 1971 to 1985, e.g. evenly distributed annually*" (JICA, 2022).

The 20-year cumulation of the land area was calculated by adding previous 20 years' data for the current year and the land remaining the same land data was calculated from total area of the land minus the current year's "converted land" area.

Uncertainty may raise due to this assumption when land use change was observed only once or twice for the period 1987-2020, then this land use change was assumed as happened by unexpected reasons and assumed no land use change was occurred in the relevant land use change during 1971-1986.

The period of the transition from old to new land use category is 20 years for carbon stock changes and one year for carbon losses. Table 6-6 shows the 20 year-cumulative changes in the land use estimated based on the main assumption and applied as an activity data for land use change in the GHG inventory.

Table 6-6: Activity data for LULUCF sector: 20 year-cumulative land changes, thousand ha

Sector	*Subsector*	*1990*	*2000*	*2010*	*2020*
Forest land	*Forest Remaining Forest*	17,102.54	17,089.28	17,079.48	17,082.30
	Land Converted to forest land	1.55	6.90	10.88	4.56
Cropland	*Cropland Remaining Cropland*	4,827.22	4,757.37	4,722.63	4,702.99
	Land Converted to Cropland	22.70	26.32	46.41	32.21
Grassland	*Grassland Remaining Grassland*	114,459.27	114,405.68	114,098.42	114,021.52

	Land Converted to Grassland	135.75	140.73	195.83	172.38
Wetlands	*Wetland Remaining Wetland*	3,246.12	3,240.94	3,207.24	3,218.87
	Land Converted to Wetland	12.25	20.72	18.72	5.39
Settlements	*Settlement Remaining Settlement*	8,463.44	8,574.26	8,608.62	8,668.46
	Land Converted to Settlement	177.67	149.07	263.01	294.19
Other land	*Other land Remaining Other land*	7,415.16	7,496.84	7,507.10	7,541.14
	Land Converted to Other land	142.78	98.34	248.11	262.44
No data		405.13	405.13	405.13	405.13
National total		156,411.58	156,411.58	156,411.58	156,411.58

6.4 Forest land (3.B.1)

Net emissions from forest land were -30,336.91 Gg CO_2e in 2020 compared with -29,367.35 Gg CO_2e in 1990, a difference was 969.56 Gg CO_2e or 3.30% increase in removals from the base year. Within the forest land category, removals from forest land remaining forest land were –30,331.10 Gg CO_2e in 2020 compared with 1990 level of -29,358.80 Gg CO_2e. The key drivers of the variation in forest land sector were forest regeneration and annual harvest. For example, about 1.0 million hectares of forests that were affected by the great fires of the 1990s and early 2000s are started regrowing naturally (MET, 2020).

6.4.1 Forest land remaining forest land (3.B.1.A)

6.4.1.1 Category description

The forest in Mongolia consists of two major types such as boreal forests in the north and the Saxaul forest in the south. The boreal forest area and its characteristics are assessed in a national forest inventory (NFI, 2019) whilst availability of detailed information on Saxaul forests remain limited. The area under forest land remaining forest land for the year 2020 was 17,082.30 thous. ha. The forest sector of Mongolia is a net sink in the GHG inventory.

Gross biomass carbon stock gains in the forest land remaining forest land were calculated increment value using forest growth table of Mongolian forest mensuration guidebook (2012). While there have been different age class volume information, increment estimates were derived based on 110 years old larch forest annual growths. Larch trees are dominant tree species in Mongolia and covers 80% of the forested areas. Larch forest is composed of Siberian pine, birch and Scotch pine tree species.

6.4.1.2 Methodological issues

6.4.1.2.1 Choice of method

The emissions from forest land remaining forest land are followed Tier 1 methodology provided in the 2006 IPCC GLs and the GPG for LULUCF to estimate carbon stock change from biomass, wood removals, and fuelwood removals associated with forest land category using equations 2.9, 2.10, 2.11, 2.12 and 2.13 from the 2006 IPCC GLs. To derive carbon stock changes for forest land remaining forest land, the working assumption is that the forest increment per hectare is stable over the inventory time period (last 20 years).

6.4.1.2.2 Activity data

The forest reference level (MET, 2018) reported that Saxaul forest area is 2,048,000 ha (±128,500 ha) and no changes occurred between 2005 and 2015, however, it is required further investigation to obtain accurate area for Saxaul forest in Mongolia.

However, above determined Saxaul forest land area is twice smaller compared to the land area determined by the Mongolian forest fund report (MET, 2020) shown in Figure 6-3. In FRDC report, Mongolian Saxaul forest were surveyed in seven aimags since 1990, totaling 4,717,980 ha. However, the Forest management planning inventory conducted the survey two or three provinces in one year, making it difficult to obtain a complete time series since 1990, thus, this data is not applicable for GHG inventory. Table 6-7 and Figure 6-3 shows the results of Saxaul forest land survey conducted by forest management planning inventory since 1990 until 2020. First year of the survey differs for each provinces due to lack of man power and financial restrictions for the year.

Table 6-7: Saxaul forest area in different provinces of Mongolia, 1990-2020

	Province names	*Initial inventories*	*Last inventories*	*Saxaul area, ha*
1.	Bayankhongor	1990, 2006	2015	787,200
2.	Gobi-Altai	1990	2011	1,664,800
3.	Dornogobi	1990, 2007	2015	116,900
4.	Dundgobi	1990, 2007	2015	32,800
5.	Uvurkhangai	1990, 2011	2020	125,500
6.	Umnugobi	1990	2011	1,189,100
7.	Khovd	1990, 2011	2020	801.7
	Total Saxaul forest area			*4,718,000*

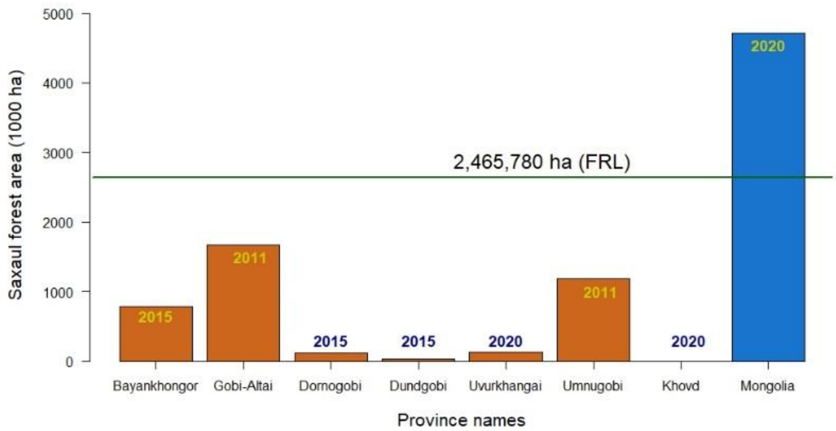

Figure 6-3: Results of Saxaul forest land survey done by the Forest management planning inventory since 1990

Furthermore, the Mongolian forest research association in collaboration with the FRDC conducted an additional study to determine the measurable Saxaul forest area using the methodology consistent with FRL and it's surveyed Saxaul forest of 2,645,780 thousand hectare. Although there was a significant amount of deforestation took place in Gobi desert, the Saxaul area statistics of FRL study shows no change which means the study was not able to capture changes of the Saxaul forest. Finally, Saxaul forest do not form dense crown cover that makes difficult to identify its changes, thus, Mongolian forestry experts agreed to use a single value of 2,645,780 ha from 1990 to 2020. The research result was submitted to the Forest resource assessment (UNFAO, 2021) and hence, Mongolia is applying the statistics produced by LULUCF assessment report 1986-2016 (CCPIU, 2018) for this report.

6.4.1.2.3 Emission factors and other parameters

Methodology from the 2006 IPCC GLs was applied to estimate carbon gains and losses. In order to improve previous inventory results and accurately reflect Mongolian country specific conditions, the emission factors were updated by improved default emission factors from the 2006 IPCC GLs (Tier 1), and the country specific values based on the latest available scientific results and assumptions. Here, emission factor for the *carbon fraction* was taken the default value from Table 4.3 (the 2006 IPCC GLs, Vol. 4) for both boreal and Saxaul forest. For emission factors such as the biomass carbon and expansion factors (BCEFs) and aboveground biomass growth were changed from IPCC default values to the country specific values; and for the aboveground and belowground biomass ratios (AGB-BGB-ratios), default litter stocks and aboveground biomass stocks were applied values obtained from the Multipurpose national forest inventory of Mongolia (MET, 2019a). The main emission factors used for the GHG estimation from forest land are listed in Table 6-8.

Table 6-8: Emission factors and other parameters applied for GHG emissions and removals in the forest land category

Emission factor	*Unit*	*Boreal forest*	*Saxaul forest*	*Sources*
Above-ground biomass growth	[t d.m./ha/yr]	0.83	0.12	Mongolian forest mensuration guidebook 2012, page 220, Table 57, Mean annual increment of 110 and 50 year old larch forests' growth used intact and degraded forests annual growths, respectively. Mongolian Forest Resources report 2021, Annex 7
Below-ground to above-ground biomass ratio	[t BGB d.m./ (t AGB d.m.)]	0.39	0.44	NFI 2019, Annex A – Data Models: Volume – Biomass – Carbon IPCC 2006, Vol. 4, Ch. 4, Table 4.4
Carbon fraction	[t C/(t d.m.)]	0.51	0.47	IPCC 2006, Vol. 4, Ch. 4, Table 4.3
Biomass carbon and expansion factor (BCEFs)	[-]	0.53	3.95	Estimation of aboveground biomass and carbon stock in Mongolian boreal forest 2017, Table 12 Allometric model development for aboveground biomass of Saxaul 2018, Table 5 data used to further develop the BCEF value
Default litter stocks	[t C/ha]	15.9	0.01	NFI 2016, Saxaul is assumed to have 10 kg litter biomass
Above-ground biomass stocks	[t d.m./ha]	67.7	4.84	NFI 2016, p103-104; 2006 IPCC GLs, Vol. 4, Ch. 4, Table 4.8
Split between Boreal and Saxaul forest	[1,000 ha]		2,645	Global Forest Resources Assessment 2020 Report Mongolia, 2020

6.4.1.3 Category-specific recalculations

Both emission factors and activity data for the category were improved and updated considering national circumstances as mentioned previous chapters. Recalculation was conducted for this category with new updated emission factors and reconstructed activity data for entire time series.

6.4.1.4 Category-specific planned improvements

There is lacking a real time accurate data for Saxaul forest area and its annual changes. Based on the information available, Saxaul forest area is considered as a rough estimates because it was conducted by different authors using different methodologies (i.e., remote sensing data, forest inventory, ancillary maps, and other sources) due to time constraints and financial limits. It is important to have an unified database within same year conducted with same methodology and to develop tree species specific parameters required for GHG inventory.

6.4.2 Land converted to forest land (3.B.1.b)

6.4.2.1 Category description

This section provides methodological guidance on annual estimation of emissions and removals of greenhouse gases, which occur on land converted to forest land from different land-uses including cropland, grassland, wetlands, settlements, and otherland, through afforestation and reforestation, either by natural or artificial regeneration.

Forest ecosystems may require a certain time to return to the level of biomass, stable soil, and litter pools of undisturbed state. With this in mind and as a practical matter, the default 20-year time interval is developed.

6.4.2.2 Methodological issues

6.4.2.2.1 Choice of method

The emissions from lands converted to forest land are followed Tier 1 methodology provided in the 2006 IPCC GLs Vol. 4 to estimate carbon stock changes associated with land converted to a new land use category. For estimating biomass changes used equations 2.9, 2.10, 2.15 and 2.16, for estimating DOM used equation 2.23 and for mineral soils used equation 2.25 from the IPCC guidelines, respectively.

6.4.2.2.2 Activity data

A 20-year-cumulitive land activity data for land converted to the forest land was calculated based on a raw data of the land use matrix for GHG inventory (ha) from 1986 to 2020 presented in ANNEX 1. Uncertainty may raise due to the main assumption that used to estimate a 20-year cumulative land activity data explained in chapter 6.3 of this report.

6.4.2.2.3 Emission factors and other parameters

In addition to Table 6-8 emission factors used for the land converted to forest land are taken from Tables 4.5, 4.9, 4.10, and 4.12 from the 2006 IPCC GLs (Vol. 4, Ch.4). Time period of the transition from old to a new land is 20 years. For boreal forest, main climate ecological zones is *boreal mountain systems* (boreal coniferous forest) and for Saxaul forest the ecological zones is selected as a *cool temperate dry* and *temperate-desert ecosystem* type and *continental* for estimating the above-ground and and below-ground biomass. Soil type is the *high activity clay mineral* and main tree species type is a *Larch*. The basic wood density (in m^3) is not selected from Table 4.13 and 4.14 due to no information available about what type of tree species planted on the new land (the 2006 IPCC GLs, Vol. 4, Ch.4).

6.4.2.3 Category-specific recalculations

This category was not included in the initial BUR because the land use change data was not available at that time. Therefore, this category has been newly calculated and included into the GHG inventory.

6.4.2.4 Category-specific planned improvements

Determining both activity data and emission factors for the category are required to be improved. No land use information was available for the years prior to 1990, thus, reconstructing activity data used for the GHG inventory requires accurate assumptions based on the historical data information such as FAOSTAT, or national statistics and professional experts' expertise. Therefore, in the future, enduring that the data conversion of the Integrated land fund classification to the international IPCC land classification is not subject to further changes and is important for data consistency.

If necessary, the first assessment of land use categories that applied for this inventory, it needs to be revised in next iterations of the national inventory.

6.5 Cropland (3.B.2)

Since 2005 crop production of Mongolia started to recover with privately owned companies assuming control of the former state-owned farms. Area of the croplands reduced significantly since 1990 out of which the most lands were abandoned until 2006. Mongolian policy states that farmers must use the abandoned land instead of exposing new lands.

Mongolia's agricultural sector is in an unfavorable and harsh environment, and herders and farmers are at high risk of zud, drought and natural disasters. The amount of production harvested each year is directly related to the climate conditions such as a cold spring, strong winds, prolonged solar overheating and prolonged cold rains that causing up to 20% decline in annual production.

6.5.1 Cropland remaining cropland (3.B.2.a)

6.5.1.1 Category description

Due to lack of activity data and country specific emission factor availability, only one climate region (*Boreal dry*) and a common soil type (*high activity clay mineral*) were used for estimating emissions from *annual crops*, only. Tier 1 method described in the 2006 IPCC GLs Vol.4 is used to make emission estimations for *annual* crops and no emissions estimated for *perennial* crops for this category.

6.5.1.2 Methodological issues

6.5.1.2.1 Choice of method

Tier 1 method described in the 2006 IPCC GLs Vol. 4 is used to make calculation for this category which calculated by equation 2.3, as a sum of changes in all carbon pools. Due to lack of activity data and country specific emission factor availability, only one climate region (*Boreal dry*) and a common soil type (*high activity clay mineral*) were used for estimating emissions from *annual crops*, respectively. No layering for *perennial crops* for Mongolia available due activity data will not be separated for this category.

6.5.1.2.2 Activity data

A 20-year-cumulitive land activity data for cropland remaining cropland was calculated based on a raw data of the land use change matrix for GHG inventory (ha) from 1986 to 2020 presented in ANNEX IV. However, activity data has no layering for *perennial crops* for Mongolia, i.e. activity data of cropland is not be separated as a *perennial* and *annual* crop types.

6.5.1.2.3 Emission factors and other parameters

Emission factors used for annual change in carbon stocks in mineral soils for this category is listed in Table 6-9. In the 2006 IPCC GLs recommend that the annual change in carbon stocks in biomass is estimated by annual growth of perennial woody biomass (ΔCG), therefore, no emission factors have been choosing for this category. Uncertainties for activity data is ±6.02% and emission factors for CO_2 is 0% for all estimations from cropland.

Table 6-9: Emission factors and other parameters applied for GHG emissions in cropland

Factor value type	*Temperature regime*	*Moisture regime*	*IPCC default*
Land use (F_{LU})	Temperate/Boreal	*Dry*	0.80
Tillage (F_{LU})	All	*Dry and moist/Wet*	1.00
Input (F_I)	Medium	*Dry and moist/Wet*	1.00

6.5.1.3 Category-specific recalculations

No category specific recalculation done for this category.

6.5.1.4 Category-specific planned improvements

This category is not identified as a key category, thus improvement is not prioritized. Future improvement is possible to obtain accurate activity data that separated for both perennial and annual crop plants.

6.5.2 Land converted to cropland (3.B.2.b)

6.5.2.1 Category description

In Mongolia, during last two decades the expansion of cropland area (especially, annual plants) has occurred dominantly from land conversion from grassland and wetlands, others conversions were insignificant. This section provides methodological guidance on annual estimation of emissions and removals of greenhouse gase, which occur on lands converted to cropland from different land uses, including forest, grassland, wetlands, settlements, and other land subcategories.

6.5.2.2 Methodological issues

6.5.2.2.1 Choice of method

Tier 1 method described in IPCC inventory guidelines is used to make calculation for this category. Calculation was conducted using equation 2.25. Due to lack of activity data and country specific emission factor availability, only one climate region (*Boreal Dry*) and a common soil type (*high activity clay mineral*) were used for estimating emissions from *annual crops*, respectively. No layering for *perennial crops* for Mongolia.

6.5.2.2.2 Activity data

Area of land converted to cropland area was calculated based on a raw data from the land use change matrix for GHG inventory (ha) from 1986 to 2020 presented in ANNEX IV. There are almost no land information was available for the years before 1990, thus, expert judgement was applied to calculate 20-year changes from 1971 to 1985 (see 6.1.3 section). Due to lack of information about crop types for the purpose of GHG inventory is main uncertainty for this subcategory.

6.5.2.2.3 Emission factors and other parameters

Emission factors for annual change in carbon stocks in mineral soils is chosen from Table 5.5 and 5.10 from the 2006 IPCC GLs and listed in Table 6-10.

Table 6-10: EF and other parameters applied for GHG emissions for land converted to cropland

Factor value type	*Temperature regime*	*Moisture regime*	*IPCC default*
Land use (F_{LU}) @ year 0	Temperate/Boreal	Dry	0.80
Land use (F_{LU}) @ year 0-T	Temperate/Boreal	Dry	1.00
Tillage (F_{mr}) @ year 0	All	Dry and moist/Wet	1.00
Tillage (F_{mr}) @ year 0-T	All	Dry and moist/Wet	1.00
Input (F_I) @year 0	Medium	Dry and moist/Wet	0.95
Input (F_I) @year 0-T	Medium	Dry and moist/Wet	1.00

Note: year 0 – last year's inventory time; year 0 -T – beginning of the inventory time period.

6.5.2.3 Category-specific recalculations

No category specific recalculation done for this category.

6.5.2.4 Category-specific planned improvements

This category is not identified as a key category, improvement is not prioritized.

Future improvement is possible if activity data can be seperated into what type of cropland (perennial or annual) the field was converted.

Land use conversion to cropland has occurred from settlements (agriculture infrastructure), and grassland. The CSC in settlements to cropland can be assumed as zero. The CSC in grassland to cropland will be considered in conjunction with grassland survey. There are three sub-categories: annual, fallow, perennial. Check amount of converted area and then this conversion and establish appropriate biomass parameters. For second BUR, it can be used default or zero, for next iteration of report recommended to use country specific data, if possible (JICA, 2022).

6.6 Grassland (3.B.3)

The amount of grazing land in Mongolia decreased by 10.1 million hectares compared to 1964 and reached 110.3 million hectares which is approximately 75% of Mongolian territory (Ministry of food, agriculture and light industry, 2019). According to the National report on the rangeland and health of Mongolia (2018), in 2016, considering the degree of degradation: 42.4% of the total grassland monitoring area is not degraded (level I or normal), 13.5% is slightly degraded (II), 21.1% is moderately degraded (III), 12.8% is severely degraded (IV), and 10.3% is It was given the value of strongly degraded (V) or loss of pasture quality, totaling 90% of pasture had changes to some extend.

6.6.1 Grassland remaining grassland (3.B.3.a)

6.6.1.1 Category description

GHG emissions and removals from grasslands, the data show a relationship between the degree of grassland degradation and carbon content in typical grasslands (steppe) in Mongolia. Because of the secular trend of increasing degraded grasslands, emissions from grasslands were calculated to be dominant, suggesting that conservation and restoration of degradation can be mutually beneficial between pure ecosystem conservation and GHG emission control (JICA, 2022).

Grassland remaining grassland category includes managed pastures which have always been under grassland vegetation and pasture use or other land categories converted to grassland more than 20 years ago (the 2006 IPCC GLs). Mongolian grassland is mostly managed as a pasture for animals and almost 60% of pasture is recoverable within 3-5 years with the right pasture management, about 40% pasture can be recovered within 5-10 years not including impacts of climate change (MEGD, 2014).

6.6.1.2 Methodological issues

6.6.1.2.1 Choice of method

In general, Tier 1 method described in the 2006 IPCC GLs is applied to make calculation for this category using equation 2.5, as a sum of changes in all carbon pools.

6.6.1.2.2 Activity data

For this report, activity data for the grassland remaining grassland was not available, specifically, grassland degradation levels by climate and geographical zones. Thus, annual change in carbon stocks in mineral soil for grassland remaining grassland category must be reported as NE or NA due to no data available for Mongolia.

6.6.1.2.3 Emission factors and other parameters

Tier 1 default values were used reference value as a SOC_{ref} as 50 ton C ha^{-1} for cold temperate and dry climate region (IPCC 2006, vol. 4, Ch.2, Table 2.3,). Other parameters are taken from Table 5.5 and 6.2 of the 2006 IPCC GLs. Annual change in carbon stocks in mineral soil for grassland remaining grassland category must be reported as NE or NA due to no data available for Mongolia.

6.6.1.3 Category-specific recalculations

No category specific recalculation done for this category.

6.6.1.4 Category-specific planned improvements

Considering Mongolian grassland has a great potential to become one of the key categories of GHG inventory it is recommended to use country specific method and/or higher Tiers of the 2006 IPCC GLs for the next iteration of the report. Carbon stock changes and relevant GHG gases emissions from Grassland in Mongolia have not estimated in the past GHG inventories. This means net emissions and removals occurred in huge area of Mongolia remains unknown. To address this not-estimated source/removal is one of the top priority issues of the LULUCF sector.

Activity data

For next ineration of the report, a new activity database needed for categories such as grassland remaining grassland and/or land converted to grassland to transfer GHG estimation into Tier 2 for each category. Currently, the NAMEM/IRIMHE grassland monitoring data described in the National report on the rangeland health of Mongolia (2018) is considered as the most reliable activity data for GHG Inventory. The grassland monitoring includes over 1516 long term monitoring sites throughout five ecological zones (High mountain, Forest steppe, Steppe, Desert steppe, and Desert) with five degradation level (I - none, II - slightly, III – moderately, IV- heavily, and V – fully) from 2014 to current year. For GHG inventory purpose, levels I and II, levels IV and V may be combined and so aboveground biomass classified only into 3 degradation classes.

The grassland degradation levels determined from the NAMEM/IRIMHE grassland monitoring data will be applied to this category from 2014 and onwards. Previously, this method was applied to a limited years 2014, 2016 and 2020, due to scope of preprocessing work and analysis of raw data. The data from 2013, 2015, 2017, 2018 and 2019 is required for the purpose of GHG inventory time series completeness. The preliminary results grassland carbon stock change (CSC) estimation based on 2014 data showed a potential of 18,000 Gg CO_2e emission which shows it may be a key source of GHG inventory (JICA, 2022).

Emission factor

Mongolia required country specific emission factors and other parameters, especially, the SOCref and the methodology how to address the changes occurred in Mongolian grassland. Thus, previously measured and analyzed research results on soil carbon stock (e.g. JICA, 2022) needs to be further evaluated and analyzed for eligibility to apply in GHG inventory.

Soil distribution under grassland should be determined by conducting belowground biomass (organic soil) survey and soil carbon survey of grasslands categorized by ecosystem types and also actual pasture management status on them.

6.6.2 Land converted to grassland (3.B.3.b)

6.6.2.1 Category description

Land converted to grassland includes forest land or other land-use categories converted to grassland within the last 20 years. Greenhouse gas inventory for the land-use category land converted to grassland involves estimation of changes in carbon stock from five carbon pools (i.e., aboveground biomass, belowground biomass, dead wood, litter, and soil organic matter), as well as emissions of non-CO_2 gases. Conversion of land from other uses and from natural states to Grassland can result in net emissions or net uptake of CO_2 from both, biomass and soil. The conversion process may also result in emissions from biomass burning from the 2006 IPCC GLs.

6.6.2.2 Methodological issues

6.6.2.2.1 Choice of method

The change in biomass carbon stock on land converted to grassland under Tier 1 should be estimated using equation 2.11 and 2.14 (the 2006 IPCC GLs). The average carbon stock change is equal to the carbon stock change due to the removal of biomass from the initial land use (i.e., carbon in biomass immediately after conversion minus the carbon in biomass prior to conversion), plus carbon stocks from biomass growth following conversion.

6.6.2.2.2 Activity data

In this report, activity data for the grassland remaining grassland and land converted to grassland were not available, specifically, grassland degradation levels by climate and geographical zones.

Area of land converted to grassland area was calculated based on a raw data from the land use change matrix for GHG inventory (ha) from 1986 to 2020 presented in ANNEX IV. There are almost no land information was available for the years before 1986, thus, expert judgement was applied to calculate 20-year changes from 1971 to 1985 (see 6.1.3 section).

6.6.2.2.3 Emission factors and other parameters

Emission factors for annual change in carbon stocks in mineral soils are taken from Table 5.5 and 5.10 from the 2006 IPCC GLs Vol. 4, Ch. 5 and listed in Table 6-11.

Table 6-11: Emission factors and other parameters applied for GHG emissions in the land converted to land converted to grassland category

Soil type	*High activity clay mineral*	*Land use (FLU)*	1.00
Reference soil organic carbon, (t C/ha)	50.00	*Management*	0.95
Carbon fraction of dry matter for woody biomass (t C/t d.m)	0.500	*Herbaceous biomass stocks present land (t d.m/ha)*	6.500
Carbon fraction of dry matter of woody biomass (t C/t d.m)	0.470	*Herbaceous biomass stocks after conversion from other land use (t d.m/ha)*	6.500

6.6.2.3 Category-specific recalculations

No category specific recalculation done for this category.

6.6.2.4 Category-specific planned improvements

Regarding the results of the grassland survey, which is a priority issue, parameters were developed, but time series calculations were not completed due to the lack of activity data. In addition, the methodologies that can be input into the software used to compile the GHG inventory are limited, so the calculation results produced on using country specific parameters (MS Excel) this time could not be reflected in the GHG inventory.

According to the GPG IPCC, Mongolia is recommended to transfer to Tier 2 if the previous land use on converted area is known.

Within JICA project (2022) it has been developed a new method for emissions and removals estimation associated with land use change based on the land matrix (ANNEX IV) in MS Excel. The method is in line with the IPCC inventory guidelines equations 2.15, 2.16 and 2. 9 (for biomass), equation 2.23 (for DOM), and equation 2.25 (for mineral soils) from the 2006 IPCC GLs Vol. 4, Ch. 2. Although this estimation was finalized for 1990 to 2020 and results are ready to use, it is not applied in the BUR2, mainly due to it is required verifications and approvals from the authorized institutions, after which needed to apply to the GHG inventory.

6.7 Wetlands (3.B.4) and Land converted to wetlands (3.B.4.b)

Mongolia GHG inventory does not include both peatlands remaining peatlands and flooded land remaining flooded land. The default methodology for land converted to flooded land provides guidance for estimation of CO_2 emission due to flooding. In the good practice guidelines recommended that "countries seeking to report CH_4 emissions from flooded lands should, where feasible, develop domestic emission factors". No country specific emission factors developed for this category. It considered that land area converted to the peatland and/or flooded land is very negligible compared to the total land cover.

6.8 Settlements (3.B.5)

This chapter provides methods for estimating carbon stock changes and greenhouse gas emissions and removals associated with changes in biomass, dead organic matter (DOM), and soil carbon on lands classified as settlements.

6.8.1 Settlements remaining settlements (3.B.5.a)

This category refers to all classes of urban formations that have been in use as settlements (e.g., areas that are functionally or administratively associated with public or private land in cities, villages, or other settlement types), since the last time data were collected. The IPCC GPG for LULUCF Ch. 3.6 does not provide methodology for this category and Mongolia does not have developed method or database related to this sector.

6.8.2 Land converted to settlements (3.B.5.b)

6.8.2.1 Category description

Conversion of forest land, cropland, grassland etc. to settlements, leads to emissions and removals of greenhouse gases. The decision tree the 2006 IPCC GLs, Vol. 2, Ch. 1, Figure 1.3 and the same basic methods can be applied to estimate change in carbon stocks in forest land, cropland and grassland converted to settlements, if needed.

6.8.2.1.1 Methodological issues

6.8.2.1.2 Choice of method

Tier 1 method from the 2006 IPCC GLs is used for estimating carbon emissions and/or removals. Dead wood and litter carbon stocks in lands converted to settlements are assumed all lost during the conversion and there is assumed to be no subsequent accumulation of new DOM in the settlements after conversion. Default values for forest litter prior to conversion are provided in the 2006 IPCC GLs Vol. Table 2.2 in Chapter 2, but there are no default values available for dead wood or litter in most systems. Carbon stocks in litter and dead wood pools in all non-forest land categories are assumed to be zero.

6.8.2.1.3 Activity data

Area of land converted to settlements area was calculated based on a raw data from the land use change matrix for GHG inventory (ha) from 1986 to 2020 presented in ANNEX 1.

6.8.2.1.4 Emission factors and other parameters

Tier 1 default values were used reference SOC as 50 ton C/ha for cool temperate, dry (the 2006 IPCC GLs Vol.4, Ch 2, Table 2.3). The carbon fraction of dead wood and litter is variable and depends on the stage of decomposition. Wood is much less variable than litter and a value of 0.50 tonne C tonne^{-1} d.m^{-1}. Can be used for the carbon fraction. Litter values in settlements range from 0.30 to 0.50. When country specific or ecosystem specific data are not available we suggest a carbon fraction value of 0.40 for litter.

6.8.2.2 Category-specific recalculations

No category specific recalculations for this category.

6.8.2.3 Category-specific planned improvements

This is not a key category, thus, no improvement is planned.

6.9 Other land (3.B.6)

The 2006 IPCC GLs defines the "other land" category as bare soil, rock, ice, and all land areas that do not fall into any of the other five land-use categories. Other land is often unmanaged, and in that case changes in carbon stocks and non-CO_2 emissions and removals are not estimated. The 2006 IPCC GLs is provided for the case of land converted to other land. Carbon pools are not assessed for this category, but it is included for checking overall consistency of land area.

6.9.1 Land converted to other land (3.B.6.b)

6.9.1.1 Category description

The conversion is associated with changes in carbon stocks or non-CO_2 emissions, most importantly those associated with conversions from forest land. Emissions and removals from forest land, cropland, grassland were estimated, emissions/removals from wetlands and settlements were negligible.

6.9.1.2 Methodological issues

6.9.1.2.1 Choice of method

The fundamental equation for estimating change in carbon stocks associated with land use conversions was introduced in Section 2.3.1.2 in the 2006 IPCC GLs Vol. 4, Ch. 2. This basic method can be applied to estimate change in carbon stocks in forest land, cropland, grassland, wetlands, and settlements converted to other land.

6.9.1.2.2 Activity data

Area of land converted to cropland area was calculated based on a raw data from the Land use change matrix for GHG inventory (ha) from 1986 to 2020 presented in in ANNEX IV. This category includes "unreported" land area which is less than 0.26% of country's total area.

6.9.1.2.3 Emission factors and other parameters

Tier 1 default values were used reference SOC as 50 ton C ha^{-1} for *cool temperate, dry zone* (the 2006 IPCC GLs, Vol. 4, Ch 2, Table 2.3). The carbon fraction of dead wood and litter is variable and depends on the stage of decomposition. Wood is much less variable than litter and a value of 0.50 tonne C tonne $d.m^{-1}$. can be used for the carbon fraction. Litter values in settlements range from 0.30 to 0.50. When country or ecosystem specific data are not available we suggest a carbon fraction value of 0.40 for litter.

6.9.1.3 Category-specific recalculations

No country specific recalculation is done.

6.9.1.4 Category-specific planned improvements

No category-specific improvement planned because this is not a key category.

6.10 Other (CRF 3.D)

6.10.1 Harvested Wood Product (HWP) (CRF 3.D.1)

Since the 1990s, due to Mongolia's transition to a market economy Mongolia has taken forest protection policy rather than exploitation, therefore, uncontrolled illegal logging, high frequency of forest fires, and the effects of harmful insects are increased. Thus, forests are deteriorating and forest losing their ecological and economic importance. A longterm trend of emissions and removals from the harvested wood products (HWP) category is given in Table 6-12.

Table 6-12: GHG emissions from HWP category from 1990-2020

Categories	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Production	661,500	443,100	424,700	425,700	379,100	194,000	205,700	56,400	253,100	56,400	99,400
GHG emission	-82.70	100.47	113.43	110.01	146.16	296.46	279.98	397.49	225.04	382.60	338.11
Categories	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	
Production	87,400	36,600	42,300	47,900	53,600	59,200	64,800	70,500	76,100	87,600	
GHG emission	340.29	374.61	361.25	348.27	335.52	323.14	311.03	299.10	284.43	268.21	
Categories	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	
Production	135,000	234,900	191,700	245,600	146,000	147,700	171,500	191,200	196,900	174,700	
GHG emission	222.56	134.23	166.95	117.75	197.13	190.59	165.85	145.34	136.89	159.50	

6.10.1.1 Category description

HWP includes all wood material (including bark) that left at the harvest site. The time carbon is held in products will vary depending on the product and its uses. For example, fuelwood and mill residue may be burned in the year of harvest and sawnwood used in buildings may be held for decades to over 100 years (the 2006 IPCC GLs, Vol. 4, page 12.5). To prevent double-counting the following statement is considered:

- HWP in SWDS and wood harvested for energy are thus implicitly treated on the basis of instantaneous oxidation (i.e. reporting no net-emissions from HWP). Estimates that are based on the sawnwood are by definition not derived from wood harvested for energy purposes (the 2013 IPCC Supplement, page 2.119) .

6.10.1.2 Methodological issues

6.10.1.2.1 Choice of method

The emissions from HWP are followed Tier 1 methodology provided in the 2006 IPCC GLs.

Activity data calculation method - Production approach

There are three default categories of HWP based on semi-finished products, a) sawnwood, b) wood-based panel, and c) paper and paperboard. Main assumptions and conditions for each category are: Cut timber generally goes to a), b) and c) above. In Mongolia, no wood-based panel production found, due to *plywood* and *particle board industries* had closed since 1993. Thus, the inflow to b) is zero (for all-time series as in the 2006 IPCC GLs, as half-live is the same for sawnwood and wood- based panel). Similarly, no paper and paperboard production were found in Mongolia and all papers are considered imported (FAO, 2023). Thus, the inflow to c) is also zero. Therefore, all timber volume can be regarded as going to 'sawnwood' (i.e. solid wood product) which has two main streams such as industrial and rural uses. A national report estimated the yield level is 40% and the 60% of timber becomes saw residue which has a quite short life time (UN-REDD, 2018), thus, the amount of sawnwood is assumed 40% of timber goes to industry.

Activity data

For HWP, activity data for solid wood product (sawnwood) was reconstructed from 1980 to 2020 based on the official data obtained from three different sources such as the Ministry of environment and tourism (MET), National statistics office (NSO) and research assumptions. Country specific activity data which cover the period from 1980 to 2020 have been applied because country specific logging data is available from 1980 which gives enough old time series for constructing the initial carbon amount of HWP for the year 1990.Table 6-136-13 shows the final results for national level solid wood products (thous. m^3) and carbon pool for HWP and method for reconstructing activity data. Timber and fuelwood volume in 1980, 1990, 1991-1993, 2000, 2001 and 2002 is calculated based on the forest outlook 2002 (Ykhanbai, 2010). Linear interpolation is applied for the share of timber and fuel wood for the year between 1981-1989, 1994, 1995-1998, and 2003-2008.

Table 6-13: Assumptions and conditions for reconstructing the activity data time series for country specific HWP

Method used for reconstruction	*Year*	*Notes*
Calculated based on the forest outlook in 2002	1980, 1990 1991 – 1993 2000 - 2002	Timber and fuel wood volume (Ykhanbai, 2010)
Liner interpolation is applied for the share of timber and fuel wood	1981 - 1989	Timber and fuelwood volume
Liner interpolation for timber volume	1994	Timber volume
Liner interpolation for fuelwood volume	1995 -1998	Fuelwood volume
Use the same timber volume as 1997	1999	Total logging volume was too small
Liner interpolation for timber volume	2003 – 2008	Timber volume
Total harvesting	1980 – 2008	Dorjsuren Chand Tungalag M., 2018
Total harvesting	2009 – 2020	MET official record is used

6.10.1.2.2 Emission factors and other parameters

Table 6-14 shows default conversion factors used for industrial round wood taken from the 2006 IPCC GLs Refinement Ch.12, Table 12.1 and 12.2.

Table 6-14: Default conversion factors for the semi-finished HWP commodity class and their subclass

Commodity classes	*Density (oven dry mass over air dry volume), mg/m3*	*Carbon fraction*	*C conversion factor (per air dry volume), mg C/m3*
Sawnwood (aggregate)	0.458	0.5	0.229
Coniferous sawnwood	0.45	0.5	0.225
Non-coniferous sawnwood	0.56	0.5	0.28
Industrial roundwood (aggregate)	0.458	0.5	0.229

6.10.1.3 Category-specific recalculations

Both emission factors and activity data for the category were improved and updated considering national circumstances. Recalculation was conducted for this category with new updated emission factors and reconstructed activity data for entire time series.

6.10.1.4 Category-specific planned improvements

Following improvements are required and needs some planning to improve GHG emissions from HWP category such as a) need to improve method for reconstructing activity data time series, b) collect real time data for fuelwood and sawnwood productions.

CHAPTER 7: WASTE

7.1 Overview of sector

This chapter includes information on the GHG emissions from the waste sector. The categories and activities for estimation methane (CH_4) and nitrous oxide (N_2O) emissions are described in detail. GHG inventory of the waste sector is based on estimating methane emissions from solid waste disposal sites, methane emissions from wastewater treatment and discharge, and nitrous oxide emissions from human sewage.

This sector is an insignificant contributor to overall national GHG emissions (excluding LULUCF) with its share of 0.58% and 250.82 Gg of CO_2 equivalents (CO_2e) in 2020. Figure 7-1 below shows the share of each sector in the overall national total GHG emissions excluding LULUCF and share of each subsector of waste sector in the year of 2020.

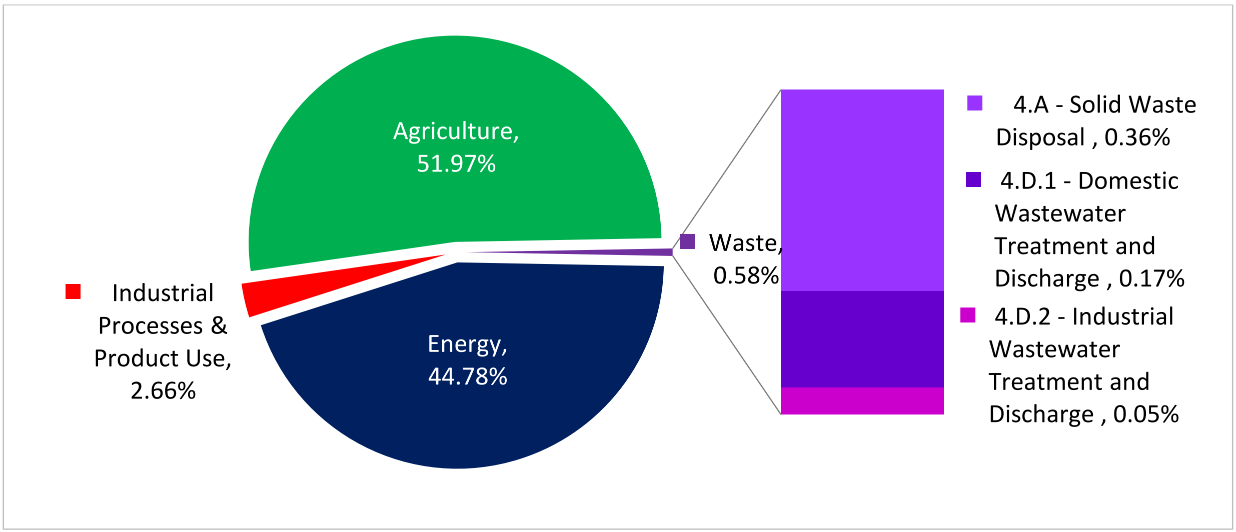

Figure 7-1: Share of each subsector of waste sector in overall national total GHG emissions (excl. LULUCF) in 2020

Total aggregated emissions from the waste sector have been increased by 350.94% from 55.62 Gg CO_2e in 1990 to 250.82 Gg CO_2e in 2020.

Table 7-1: Emissions from waste sector in 1990 and 2020

Source categories	*Gas*	*Emissions, Gg CO_2e*		*Change from 1990 ($Gg\ CO_2e$)*	*Change from 1990 (%)*
		1990	*2020*		
4.A - Solid waste disposal	CH_4	15.33	155.63	140.29	914.88%
4.D.1 - Domestic wastewater treatment and discharge	CH_4	19.44	47.11	27.66	142.28%
4.D.1 - Domestic wastewater treatment and discharge	N_2O	12.39	27.27	14.88	120.14%
4.D.2 - Industrial wastewater treatment and discharge	CH_4	8.46	20.82	12.36	146.19%
4. Waste Total	CO_2e	55.62	250.82	195.20	350.94%

In 2020, methane emissions from Solid Waste Disposal Sites (SWDS) has increased by 914.88% and methane emissions from industrial wastewater treatment and discharge has increased by 146.19%, methane and nitrous oxide emissions from domestic wastewater treatment and discharge have increased by 142.28% and 120.14%, respectively, compared to the base year.

The GHG emission trends in this sector are presented in Table 7-2 and Figure 7-2.

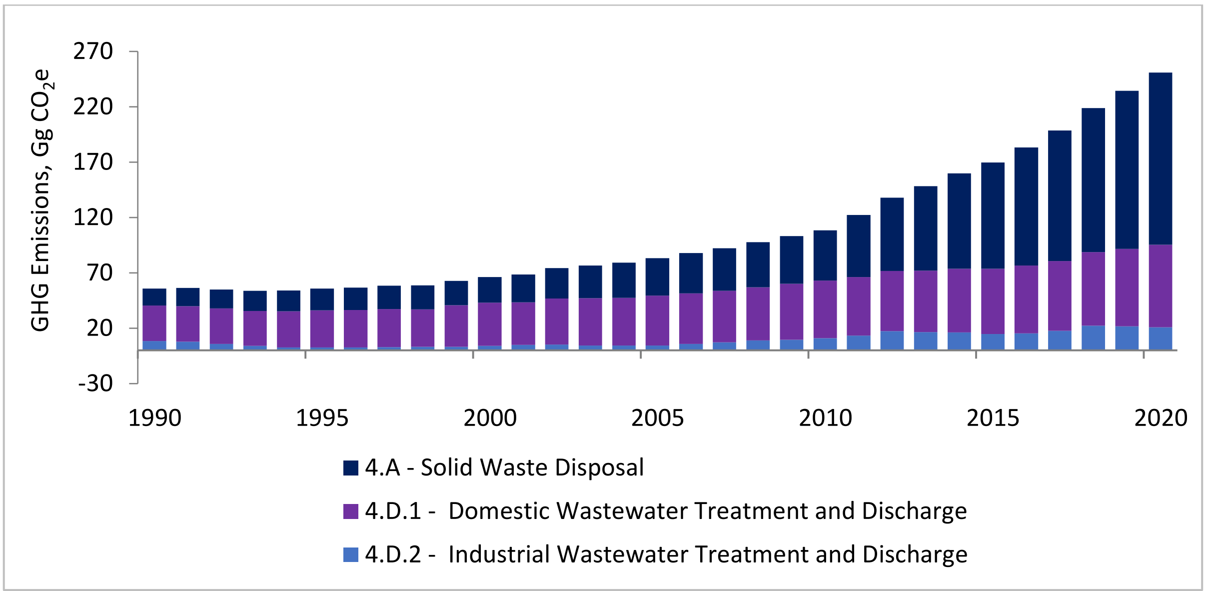

Figure 7-2: Trend of GHG emissions in the waste sector by source categories in 1990-2020, Gg CO_2e

The emissions from SWDS contributed 62.05%, Domestic wastewater treatment and discharge 29.65% and Industrial wastewater treatment and discharge 8.30% to waste sector's total emissions in 2020 (Table 7-2).

Table 7-2: GHG emissions from waste sector by source categories, Gg CO_2e

Categories	*Emissions*	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*
4.A - Solid waste disposal	(Gg)	15.33	19.60	22.92	34.00	45.27	95.94	155.63
	%	27.57	35.19	34.70	40.80	41.82	56.62	62.05
4.D.1 - Domestic wastewater	(Gg)	31.83	33.49	39.24	45.03	52.14	58.72	74.38
	%	57.23	60.11	59.43	54.05	48.17	34.65	29.65
4.D.2 - Industrial wastewater	(Gg)	8.46	2.62	3.87	4.29	10.85	14.80	20.82
	%	15.20	4.71	5.87	5.15	10.02	8.73	8.30
4. Waste Total	Gg	55.62	55.71	66.03	83.32	108.26	169.46	250.82
	%	100	100	100	100	100	100	100

Emissions from SWDS and the Wastewater treatment and discharge determined the waste sector emission trends. As seen from Figure 7-2 and Table 7-2, CH_4 and N_2O emissions from SWDS and Domestic wastewater treatment and discharge have increased continuously year by year in relation to the growing populations, operational and management challenges at some landfill sites, and the country's poor state of domestic wastewater treatment facilities. Meanwhile, the emission trend of methane from industrial wastewater treatment and discharge was fluctuating due to the certain year's economic condition.

7.1.1 Methodological issues

The emissions from waste sector were calculated using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC GLs) and applying the Tier 1 and Tier 2 methods. The selection of methods followed the decision trees in the 2006 IPCC GLs.

The approaches and emission factors applied in estimations of GHG emissions from source categories of the waste sector are presented in Table 7-3.

Table 7-3: Methods and emission factors used in estimations of emissions from waste sector

IPCC code	*Source categories*	*CH_4*	*N_2O*
		Method applied/EF	
4.	*WASTE*	T1/T2/D	-
4.A	*Solid Waste Disposal*	T1/ T2/D	-
4.D	*Wastewater Treatment and Discharge*	T1/D	T1/D

Abbreviations: T1 = Tier 1 method, T2 = Tier 2 method, EF = emission factor, D = 2006 IPCC GLs default value

7.1.2 Key categories

There is found no key category in the waste sector in the national level key category analysis (KCA). The total emissions from this sector are insignificant by contributing only 0.58% to the national total emissions. The SWDS and Domestic wastewater treatment and discharge are the major sources for emissions under the waste sector in 2020.

7.1.3 Uncertainty assessment and time series consistency

The uncertainty estimation of CH_4 and N_2O emissions from the waste sector has been done according to the Tier 1 method presented in the 2006 IPCC GLs. It was estimated based on uncertainty default values for the activity data and emission factors and some uncertainty values were selected by expert judgment due to the lack of information on some source categories. The detailed uncertainty values used in uncertainty assessment are presented under each source category described below. The results of the uncertainty analysis for all subcategories have been presented in Annex III. The time series was checked for the consistency. In the next iteration, the investigation will be performed with a view to collecting more accurate data.

7.1.4 Quality assurance and Quality control (QA/QC)

In the current submission, all applied information and data have been double-checked as far as possible. General quality control (QC) procedures were applied in the waste sector according to the 2006 IPCC GLs, Vol.1, Ch.6, Table 6.1. For instance, activity data (AD) of population is taken from Statistical yearbooks and cross-checked against the National Statistic Office (NSO) website information. GHG emissions were estimated using activity data default factors and parameters from official sources of reference.

The different sectoral inventory experts cross-checked the activity data and emission factors (EFs) and/or other parameters for each other's sectors. All AD, EFs, assumptions and calculations were documented and archived both in hard copies and electronically.

7.1.5 Source specific recalculations

There have been no recalculations of emissions for this sector.

7.1.6 Assessment of completeness

The current inventory covers greenhouse gas emissions from 3 subcategories: Solid waste (4.A), Domestic wastewater treatment and discharge (4.D.1) and Industrial wastewater treatment and discharge (4.D.2) from 1990 to 2020. Table 7-4 shows the overview of the completeness status of the estimations under various source categories within the sector.

Table 7-4: Assessment of completeness of GHG emissions under the waste sector

Source categories	*Status of gas*		
	CO_2	*CH_4*	*N_2O*
4.A - Solid waste disposal	-	E	-
4.B - Biological treatment of solid waste	-	NE	NE
4.C - Incineration and open burning of waste	-	NO	NO
4.D - Wastewater treatment and discharge	-	E	E

Abbreviations: E-Estimated, source categories included in the inventory; NO-Not Occurring; NE-Not Estimated

7.1.7 Source specific planned improvements

All activity data and other parameters used for estimation of emissions from waste sector will be kept under investigation, will be updated by its availability, and will be considered apply them in next iterations of inventory.

7.2 Solid waste disposal (4.A)

7.2.1 Category description

CH_4 emissions from Solid Waste Disposal (SWD) cover emissions from managed and un-managed waste disposal sites and it is calculated using the First Order Decay (FOD) method from the year 1970.

Compared to 1990, total emissions from the SWD have increased by 140.29 Gg CO_2e (914.88%) due to First order decay calculation method. CH_4 emissions from SWDS are presented in Figure 7-3.

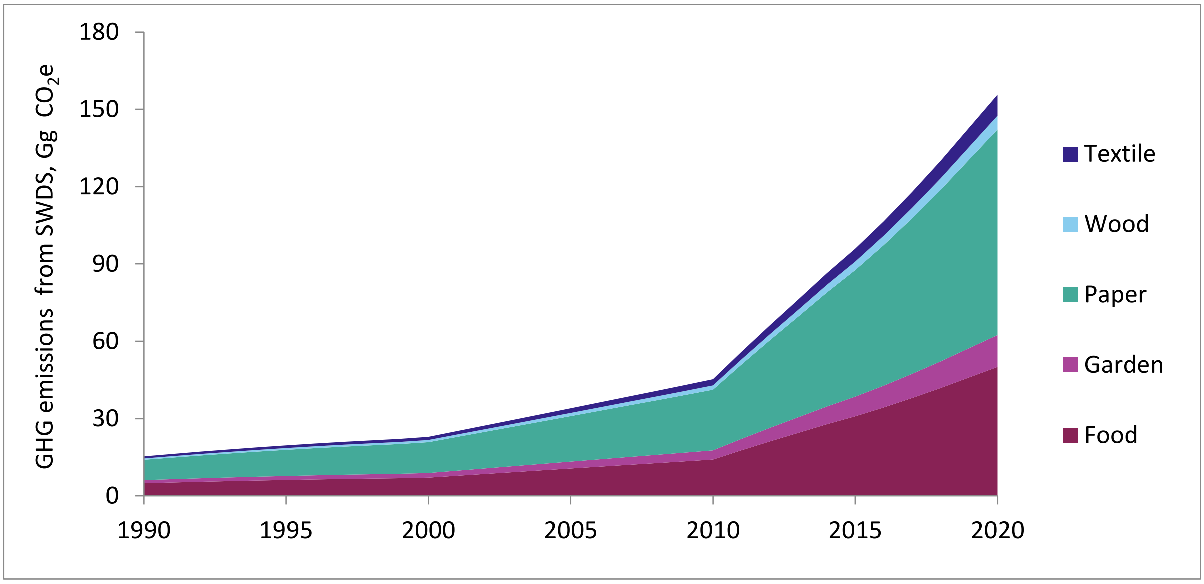

Figure 7-3: Quantities of CH_4 emissions from biodegradable solid waste disposed in SWDS, 1990–2020, Gg CO_2e

CH_4 emissions from biodegradable solid waste disposed in SWDS presented in Table 7-5.

Table 7-5: Quantities of CH_4 emissions from biodegradable solid waste disposed in SWDS, 1990–2020, Gg CH_4

Year	*Food*	*Garden*	*Paper*	*Wood*	*Textile*	*Total*	*Total emissions from SWDS*
	Gg CH_4						*Gg CO_2e*
1990	0.23	0.06	0.38	0.03	0.04	0.73	15.33
1991	0.25	0.06	0.40	0.03	0.04	0.77	16.27
1992	0.26	0.06	0.42	0.03	0.04	0.82	17.19
1993	0.27	0.07	0.44	0.03	0.05	0.86	18.03
1994	0.28	0.07	0.46	0.03	0.05	0.90	18.85
1995	0.29	0.07	0.48	0.03	0.05	0.93	19.60
1996	0.30	0.08	0.50	0.03	0.05	0.97	20.32
1997	0.31	0.08	0.52	0.04	0.05	1.00	20.97
1998	0.32	0.08	0.53	0.04	0.05	1.03	21.55
1999	0.33	0.08	0.55	0.04	0.06	1.05	22.12
2000	0.34	0.09	0.57	0.04	0.06	1.09	22.92
2001	0.37	0.09	0.62	0.04	0.06	1.20	25.14
2002	0.41	0.10	0.68	0.05	0.07	1.30	27.35
2003	0.44	0.11	0.73	0.05	0.07	1.41	29.55
2004	0.47	0.12	0.79	0.06	0.08	1.51	31.78
2005	0.51	0.13	0.84	0.06	0.09	1.62	34.00
2006	0.54	0.14	0.90	0.06	0.09	1.73	36.24
2007	0.57	0.14	0.95	0.07	0.10	1.83	38.48
2008	0.60	0.15	1.01	0.07	0.10	1.94	40.71
2009	0.64	0.16	1.06	0.08	0.11	2.05	42.97
2010	0.67	0.17	1.12	0.08	0.11	2.16	45.27
2011	0.84	0.21	1.37	0.09	0.14	2.66	55.88
2012	1.01	0.25	1.62	0.11	0.17	3.15	66.19
2013	1.17	0.29	1.86	0.13	0.19	3.63	76.23
2014	1.32	0.33	2.11	0.14	0.22	4.11	86.39
2015	1.47	0.36	2.34	0.16	0.24	4.57	95.94
2016	1.63	0.40	2.60	0.17	0.27	5.07	106.53
2017	1.81	0.45	2.88	0.19	0.29	5.62	117.95
2018	1.99	0.49	3.17	0.21	0.32	6.19	130.01
2019	2.19	0.54	3.48	0.23	0.36	6.80	142.85
2020	2.38	0.59	3.80	0.26	0.39	7.41	155.70
Diff. % 1990/2020	920.93	915.35	912.13	916.62	912.13	915.35	915.35
Diff. % 2019/2020	8.86	8.96	9.06	9.20	9.06	8.99	8.99

As seen from Figure 7-3, the quantities of emitted methane from SWDS have an increasing trend, because of population growth, especially in urban areas. The methane emissions have rapidly increased for the last decade, due to waste disposed to the well-managed landfills which used to covered with soil since 2010 in Ulaanbaatar. Another main factor which affected to the increase of emission estimation is application of the FOD method for the SWD source category.

7.2.2 Methodological issues

7.2.2.1 Choice of method

The CH_4 emissions from domestic and commercial solid waste disposal sites (managed and un-managed) were estimated according to the 2006 IPCC GLs by using the FOD method. The emissions were estimated taking into account the population, per capita waste generation, and quantity collected and deposited of waste disposal sites. The quantity of CH_4 emitted during the decomposition process is directly proportional to the fraction of Degradable Organic Carbon (DOC), which is defined as the carbon content of different types of organic biodegradable wastes such as paper and textiles, garden and park waste, food waste, wood and straw waste.

7.2.2.2 Activity Data

Incomplete data for Municipal Solid Waste (MSW) in Mongolia makes it difficult to accurately determine GHG emissions from the waste sector. The amount of waste generation is available only from Ulaanbaatar city. The accurate quantity amounts of MSW generated from other urban and rural areas of Mongolia are not available. Therefore, the amounts of MSW from the urban areas were calculated by multiplying the per capita waste generation rates with the number of urban population. Data on urban population obtained from the dataset of the NSO.

The generation rates were assumed as the follows and it can be divided into three periods:

- 1970-1999: 0.334 kg/cap/day (WMO, 2003),
- 2000-2009: 0.600 kg/cap/day (World bank, 2006),
- 2010-2020: 0.840 kg/cap/day (Namkhainyam B.et al., 2014).

The fraction of the MSW disposed to SWDS assumed as 65% by national experts and applied for the period of 1990-2014 (Namkhainyam B. et al., 2014). Futhermore, the overall waste collection coverage is assumed to be 70% in urban areas and in Ulaanbaatar and it was 90–95% in 2020. The fraction for the period of 2015-2020 obtained by intropolations.

The country specific data of waste composition were taken from the research report by Namkhainyam B. et al. (2014). The composition of waste is presented in Figure 7-4 which was applied for the entire period of 1990–2020.

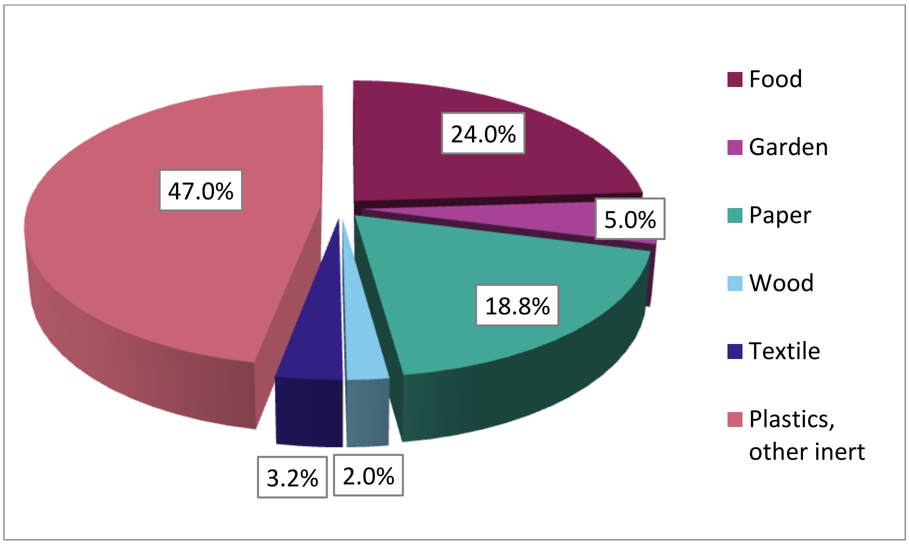

Figure 7-4: Composition of waste,%

In 2020, Mongolia's total urban population was 3,357,542 and 2,316,499 or 2/3 of the total urban population live in Ulaanbaatar city. Therefore, it was assumed that approximately 2/3 of the total waste is generated only from Ulaanbaatar. There are 3 operational controlled landfill sites in Ulaanbaatar city. In Mongolia's case, the first regulated municipal solid waste disposal site, namely Moringiin davaa, which started its operation in 1970. Thus, to estimate the CH_4 emissions from SWDS by using the FOD method, the time series for disposed waste amounts were estimated from the 1970 (detailed in Table 7-6).

Table 7-6: Urban population and estimated MSW in urban areas of Mongolia

Indicators	*Units*	*1970*	*1980*	*1990*	*2000*	*2005*	*2010*	*2015*	*2020*
Population	thous. person	541.60	839.00	1,226.53	1,361.27	1,579.39	1,910.75	2,096.18	2,316.50
Generated Waste	Gg	66.03	102.28	149.53	298.12	345.89	586.22	643.11	710.70
Deposited MSW	Gg	42.92	66.48	97.19	193.78	224.83	381.04	444.79	584.47
Biodegradable waste	Gg	22.75	35.24	51.51	102.70	119.16	201.95	235.74	309.77

7.2.2.3 Emission factor and other parameters

All solid waste disposal sites in Mongolia, in particular in the Ulaanbaatar city, were un-managed before 2009 which mainly up to 5 meters soil cover. From the end of 2009, a landfill technology was started to be used at the operational SWDSs of Ulaanbaatar city by covering 8-10 ha areas processing annually on these sites. Thus, calculations made under solid waste disposal comprise of managed as well as un-managed disposal sites.

The solid waste disposal sites in Mongolia categorized into the un-managed shallow type according to the IPCC guidelines before 2009 and then divided into un-managed and managed type since 2010. Based on this national circumstance, the methane correction factor (MCF) was varied for the inventory period. For example, MCF of 0.4 is taken as default value for emission estimation between 1970 and 2009 and then in the later period of inventory (2010-2020), MCF of 1.0 is applied for the managed landfill sites; and 0.4 (default value) for un-managed sites for emission estimation. In the period of 2011-2020, share percentage between un-managed and managed SWDS are 31-32% and 68-69%, respectively. The MCFs were applied for emission estimations are presented in the Table 7-7.

Table 7-7: MCF distribution in solid waste disposal

Year	SWDS classification		Weighted MCF
	Unmanaged –shallow, %	Managed – anaerobic, %	
1970-2009	100	0	0.400
2010	35	65	0.790
2011-2020	31-32	68-69	0.800-0.814

The quantity of CH_4 emitted during decomposition process is directly proportional to the fraction of degradable organic carbon (DOC), which is defined as the carbon content of different types of organic biodegradable wastes such as paper and textiles, garden and park waste, food waste, wood and straw waste. The values that have been applied for calculations are reported in Table 7-8.

Table 7-8: Variables used in the calculations of methane from landfills

Variables	*Type of waste*				
	Food	*Garden*	*Paper*	*Wood*	*Textile*
DOC	0.15	0.20	0.40	0.43	0.24
DOCf	0.5	0.5	0.5	0.5	0.5
CH_4 generation rate constant, k	0.06	0.05	0.04	0.02	0.04
Half-life time ($t_{1/2}$, years), h	11.60	13.90	17.33	34.70	17.30
Process start in deposition year. Month, M	13	13	6	13	13
Fraction to CH_4	0.5	0.5	0.5	0.5	0.5

7.2.2.4 Uncertainties and time-series consistency

The uncertainty estimation of the 2020 inventory has been done according to the Tier 1 method presented in the 2006 IPCC GLs. The IPCC recommended default values were used as the source of uncertainty values and taken from the 2006 IPCC GLs, Vol. 5, Ch.3, which are presented in Table 3.5. However, expert judgment was performed on selecting values applicable for GHG emissions estimation from SWD which are presented in Table 7-9. The time series was checked for the consistency.

Table 7-9: Estimated values of uncertainties in MSW disposal

Input	*Uncertainties*
Activity data	
CH_4 emissions from Solid waste disposal	
Total of MSW	±30%
Fraction of MSW sent to SWDS	±30%
Total uncertainty of waste composition	±30%
Emission factor	
Degradable organic carbon	±10%
Fraction of Degradable organic carbon (DOCf)	±15%
MCF:	
=1.0	-10%, +0%
=0.4	±30%
Fraction of CH_4 in generated Landfill gas (F)	±5%
Total uncertainty of the Half-life ($t_{1/2}$)	
Paper textile	17 (14-23)
Wood	35 (23-69)
Garden	14 (12-17)
Food	12 (9-14)

7.2.3 Category-specific recalculations

There have been no recalculations done for emissions from this category.

7.2.4 Category-specific planned improvements

As reported above there is still a lack of activity data. Thus, the following activities are planned for the emissions estimations:

- update the historical data on waste generation per capita
- refine information of the distribution of waste by waste management type.

7.3 Biological Treatment of Solid Waste (4.B)

Biological treatment of waste was not occurring for the entire inventory period hence emissions were not estimated for this source. In recent years, different types of fertilizers produced using secondary products from poultrymanure, wool, food waste etc. If activity data of these sources is available, the GHG emission will be estimated and included in the next iteration .

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

The Law on Waste was approved by a parliamentary resolution on May 12, 2017 with a new amendment consisting of 8 chapters and 43 articles. In accordance with this law, it was prohibited following activities: i) the open burning of all types of waste; ii) the burning of synthetic waste in households or low-pressure stoves for individuals and organizations. Mongolia doesn't have any waste incineration plant. Therefore, these subcategories are reported as not occurring (NO).

7.5 Wastewater Treatment and Discharge (4.D)

This category covers emissions generated during municipal and industrial wastewater treatments. When the wastewater is treated anaerobically, methane is produced. Wastewater handling can also be a source of N_2O. Therefore, N_2O emissions from human sewage are also part of the inventory. The emissions of methane and nitrous oxide from wastewater treatment by source categories are increasing year by year. In 2020, methane emissions from Industrial wastewater treatment and discharge decreased by 3.94%, compared with 2019. This is due to the decline in industrial production during the COVID-19 pandemic.

The GHG emission trends from the Wastewater treatment and discharge are presented in Table 7-10 and Figure 7-5.

Table 7-10: CH_4 and N_2O emissions from wastewater treatment and discharge

Year	*Domestic wastewater CH_4 emissions*	*Domestic wastewater N_2O emissions*	*Industrial wastewater CH_4 emissions*	*Domestic wastewater CH_4 emissions*	*Domestic wastewater N_2O emissions*	*Industrial wastewater CH_4 emissions*	*Wastewater treatment and discharge Total emissions*
	(Gg CH_4)	*(Gg N_2O)*	*(Gg CH_4)*	*(Gg CO_2 e)*			
1990	0.93	0.04	0.40	19.44	12.39	8.46	40.29
1991	0.94	0.04	0.37	19.67	12.52	7.72	39.91
1992	0.92	0.04	0.27	19.34	12.80	5.63	37.77
1993	0.94	0.04	0.19	19.66	12.07	3.90	35.62
1994	0.94	0.04	0.13	19.78	12.73	2.64	35.15
1995	0.95	0.04	0.12	20.05	13.43	2.62	36.11
1996	0.96	0.04	0.12	20.10	13.72	2.43	36.24
1997	0.97	0.05	0.14	20.30	14.09	2.91	37.30
1998	0.99	0.04	0.15	20.77	13.13	3.12	37.02
1999	1.08	0.05	0.15	22.63	14.76	3.19	40.58
2000	1.11	0.05	0.18	23.36	15.88	3.87	43.12
2001	1.15	0.05	0.23	24.12	14.28	4.92	43.31
2002	1.19	0.05	0.25	24.96	16.62	5.23	46.81
2003	1.24	0.05	0.21	26.03	16.52	4.41	46.96
2004	1.28	0.05	0.21	26.86	16.03	4.36	47.25
2005	1.34	0.05	0.20	28.06	16.97	4.29	49.33
2006	1.38	0.05	0.27	28.97	16.91	5.62	51.50
2007	1.42	0.05	0.34	29.75	16.91	7.11	53.77
2008	1.47	0.06	0.43	30.90	17.08	8.96	56.95
2009	1.53	0.06	0.46	32.12	18.45	9.57	60.13
2010	1.61	0.06	0.52	33.89	18.25	10.85	62.99
2011	1.63	0.06	0.63	34.23	18.83	13.20	66.26
2012	1.67	0.06	0.82	35.13	19.28	17.20	71.61

2013	1.72	0.06	0.78	36.17	19.44	16.32	71.93
2014	1.74	0.07	0.76	36.48	21.02	16.02	73.52
2015	1.79	0.07	0.70	37.66	21.05	14.80	73.52
2016	1.89	0.07	0.73	39.65	21.68	15.29	76.63
2017	1.94	0.07	0.83	40.68	22.56	17.48	80.72
2018	2.03	0.08	1.06	42.57	23.91	22.24	88.72
2019	2.14	0.08	1.03	45.00	24.82	21.67	91.49
2020	2.24	0.09	0.99	47.11	27.27	20.82	95.19
Diff. % 1990/2020	142.28	120.14	146.19	142.28	120.14	146.19	136.29
Diff. % 2019/2020	4.68	9.88	-3.94	4.68	9.88	-3.94	4.05

By 2020, share percentages of the each source contribution to the Wastewater treatment and discharge were changed as follows: CH_4 emissions from Domestic wastewater treatment and discharge (49.49%), N_2O emissions from Domestic wastewater treatment and discharge (28.65%) and CH_4 emissions from Industrial wastewater treatment and discharge (21.87%). The emissions of CH_4 and N_2O from wastewater treatment by source categories are shown in the Figure 7-5.

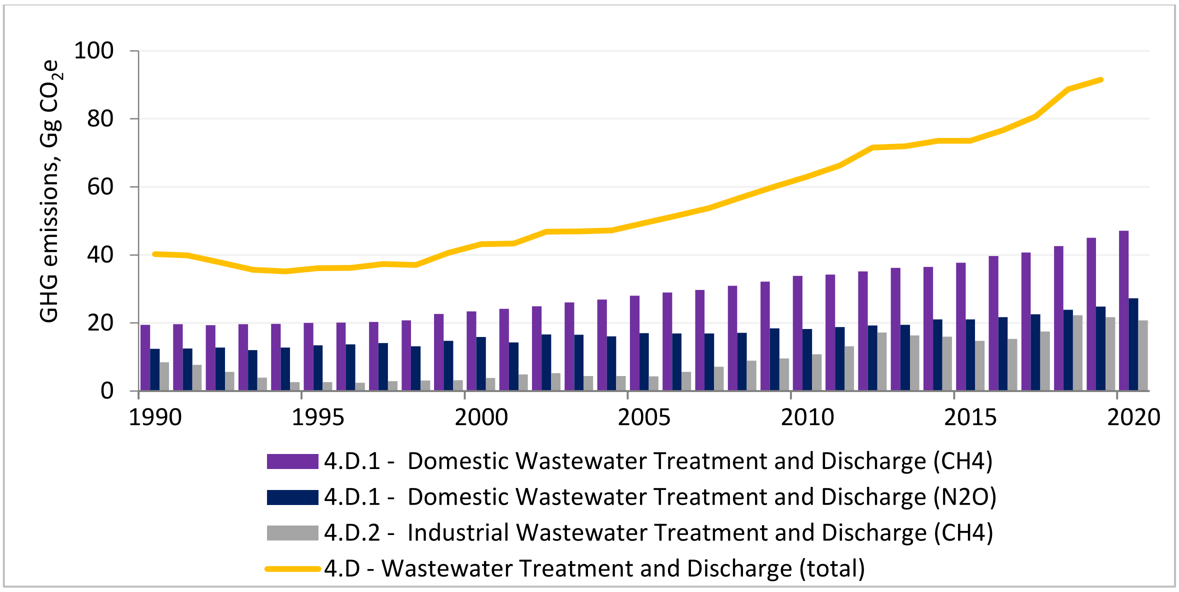

Figure 7-5: Emissions of methane and nitrous oxide from wastewater treatment by source categories, Gg CO_2e

7.5.1 Domestic Wastewater Treatment and Discharge

7.5.1.1 Category description

GHG emissions from the Domestic wastewater treatment and discharge sector have increased by 54.91 Gg CO_2e (136.29 %) in 2020 from the 1990 level of 40.29 Gg CO_2e. The total CO_2e emission from waste sector in 2020 increased by 4.05% compared with 2019. The activities for estimating methane (CH_4) and nitrous oxide (N_2O) emissions from this subcategory are described in detail.

The total amount of CH_4 emissions from domestic wastewater treatment in 2020 was 2.24 Gg CH_4. This was 142.28% and 4.68% above 1990 and 2019 levels, respectively.

Administratively, Mongolia divided into the capital city, Ulaanbaatar, 21 provinces called aimag, and aimags divided into soums. Therefore, population of Ulaanbaatar city was considered as urban high income group, the population of 21 provinces as urban low income group, and population of soums as a rural group. The CH_4 emission trend of domestic wastewater treatment and discharge by income groups are presented in Figure 7-6.

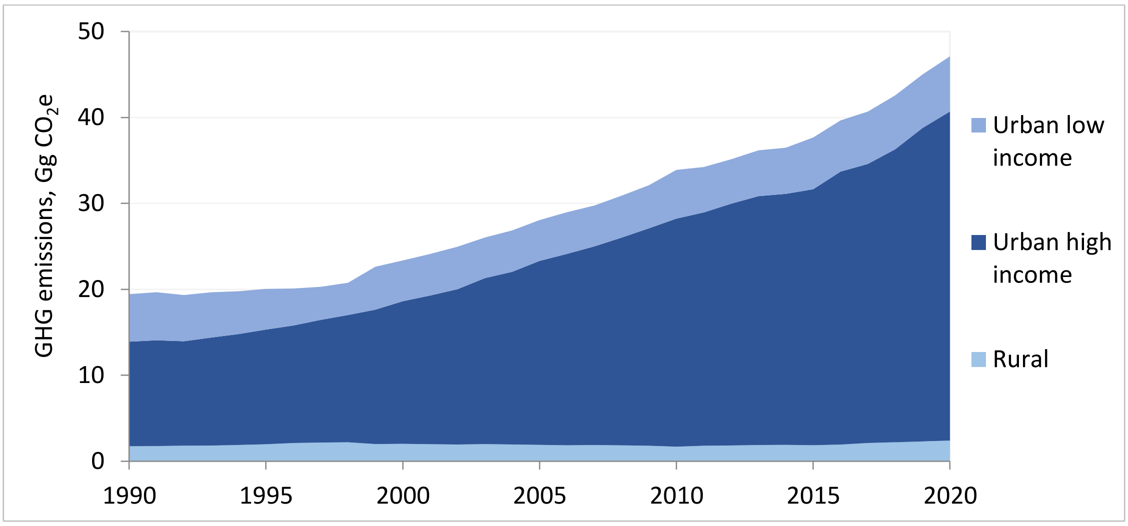

Figure 7-6: CH_4 emissions from domestic wastewater treatment, by income groups, Gg CO_2e

N_2O Emissions

The total N_2O emissions from domestic wastewater treatment in 2020 was 0.09 Gg N_2O. This represented a 120.14% increase compared with 1990 and a 9.88% increase compared to 2019. N_2O emissions from wastewater domestic sources for the period 1990-2020 are shown in Figure 7-7.

As shown in Figure 7-7, the quantities of emitted nitrous oxide from domestic wastewater sources has an increasing trend, depends on the increasing population, especially, in urban areas. Minor fluctuation in time series is related to the changes per capita protein consumption values. Due to a very high global warming potential of N_2O, relatively low amounts of N_2O formation can substantially contribute to GHG emissions. Referring to the IPCC Second Assessment Report (SAR), 1g N_2O has the greenhouse effect of 310 g CO_2.

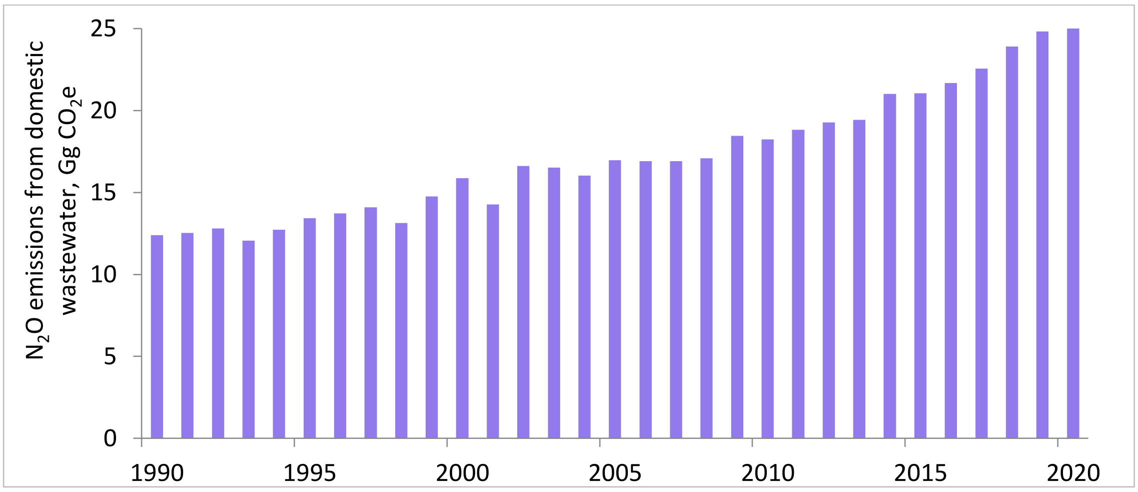

Figure 7-7: N_2O emissions from wastewater domestic sources, Gg CO_2e

7.5.1.2 Methodological issues

7.5.1.2.1 Choice of method

CH_4 Emissions

The methane emissions from domestic wastewater have been calculated using the Tier 1 methodology of the 2006 IPCC GLs, Vol.5, Ch.6, equation 6.1, 6.2 and 6.3.

N_2O Emissions

The nitrous oxide emissions from domestic wastewater have been calculated using Tier 1 methodology of the 2006 IPCC GLs, Vol.5, Ch.6., by equation 6.7 and 6.8.

7.5.1.2.2 Activity data

CH_4 Emissions

In 2015, approximately 25.19% of households were connected to centralized aerobic wastewater treatment plants. The 47.58% of households use latrines, 26.80% of households lack wastewater disposal points and only 0.42% use septic tanks (NSO, 2016).

In 2020, according to the Mongolian population and housing census, approximately 29.66% of households were connected to centralized aerobic wastewater treatment plants. The 49.24% of households use latrines, 20.46% of households lack wastewater disposal points and only 0.64% use septic tanks (NSO, 2021b).

Wastewater treatment and discharge systems usage differ for rural and urban residents. Hence, a factor U is introduced to express each income group fraction. It is good practice to treat the three categories: rural population, urban-high income population, and urban-low income population, separately.

Number of inhabitants included into various types of domestic wastewater treatment by category presented in Table 7-11.

Table 7-11: Number of inhabitants included into various types of domestic wastewater treatment

Year	*Number of inhabitants, person*			
	Urban high income	*Urban low income*	*Rural*	*Total**
1990	533,099	565,616	372,549	1,471,264
1991	537,884	573,732	376,288	1,487,904
1992	533,484	558,808	377,444	1,469,736
1993	547,086	552,393	379,792	1,479,271
1994	565,227	515,922	402,433	1,483,582
1995	583,850	494,912	418,273	1,497,035
1996	603,124	457,575	440,013	1,500,712
1997	623,814	406,857	466,592	1,497,263
1998	649,889	393,568	474,236	1,517,693
1999	691,193	516,267	413,562	1,621,022
2000	722,705	500,456	418,730	1,641,891
2001	753,860	501,188	416,401	1,671,449
2002	792,540	499,933	413,243	1,705,716
2003	843,082	495,219	404,880	1,743,181
2004	882,654	492,252	399,448	1,774,354
2005	923,877	497,713	390,540	1,812,130
2006	958,040	501,894	386,469	1,846,403

2007	999,217	491,700	387,856	1,878,773
2008	1,043,659	499,494	382,959	1,926,112
2009	1,088,334	508,885	379,165	1,976,384
2010	1,131,668	588,576	341,718	2,061,962
2011	1,170,453	538,134	367,903	2,076,490
2012	1,198,671	537,518	378,250	2,114,439
2013	1,247,697	550,922	375,616	2,174,235
2014	1,239,451	554,171	404,177	2,197,799
2015	1,269,746	618,254	386,481	2,274,481
2016	1,326,523	616,640	409,687	2,352,850
2017	1,364,147	615,676	440,643	2,420,466
2018	1,407,838	642,293	457,843	2,507,974
2019	1,471,326	659,871	469,871	2,601,068
2020	1,544,679	666,053	484,523	2,695,255
Diff. % 1990/2020	189.75	17.76	30.06	83.19
Diff. % 2019/2020	4.99	0.94	3.12	3.62

** - Excluding population with lack of wastewater disposal points.*

N_2O emissions

The country's population has been obtained from NSO. According to the Mongolian population and housing census approximately 29.66% of households were connected to centralized aerobic wastewater treatment plants in 2020.

The average consumption of protein per inhabitant in every individual year has been obtained from the nutrition statistics of NSO. The consumption data had not been available for the years 1990 and 1991, average value for the years 1992-1994 have been applied for the years, where are missing data. Data on population and annual protein intake are presented in Table 7-12.

Table 7-12: Population and protein consumption in the period 1990-2020

Year	*Population*	*Protein consumption (kg/person/year)*	*Year*	*Population*	*Protein consumption (kg/person/year)*
1990	542,458	33.48	*2006*	650,722	38.11
1991	548,440	33.48	*2007*	660,090	37.56
1992	543,691	34.53	*2008*	671,554	37.30
1993	547,101	32.34	*2009*	684,230	39.53
1994	555,916	33.58	*2010*	695,488	38.47
1995	565,011	34.86	*2011*	708,259	38.98
1996	573,328	35.08	*2012*	722,385	39.13
1997	581,255	35.55	*2013*	738,137	38.62
1998	589,480	32.67	*2014*	754,680	40.84
1999	597,883	36.21	*2015*	770,254	40.08
2000	605,342	38.47	*2016*	813,991	39.06
2001	612,720	34.16	*2017*	857,397	38.58
2002	621,099	39.24	*2018*	902,564	38.84
2003	628,513	38.54	*2019*	948,508	38.36
2004	635,225	37.01	*2020*	995,798	40.15
2005	642,617	38.73			

7.5.1.2.3 Emission factors and other parameters

CH_4 Emissions

Degrees of treatment utilization (T) for each income group (U) used in methane estimation of emissions, presented in Table 7-13.

Table 7-13: Degrees of treatment utilization (T) for each income group (U), 2020

Income group	*Type of treatment and discharge pathways*	*Treatment utilization, (%)*
Urban high income	To centralized aerobic treatment plant	27.54
	Latrine	27.80
	Septic tank	0.39
Urban low income	To centralized aerobic treatment plant	8.35
	Latrine	16.68
	Septic tank	0.25
Rural	To centralized aerobic treatment plant	1.40
	Latrine	17.43
	Septic tank	0.16

Note: Columns do not add up to 100% due to rounding.

For domestic wastewater, Biochemical Oxygen Demand (BOD) is the recommended parameter used to measure the degradable organic component of the wastewater. The BOD concentration indicates only the amount of carbon that is aerobically biodegradable. According to the Mongolian construction norms and rules 40-01-06 the BOD value is 40 g/cap/day (MCUD, 2006). The IPCC default as well as national standards value of 40 g BOD/person/day or 14600 kg BOD/1000 person/year was used for emission calculations.

The IPCC default values of the correction factor for additional industrial BOD discharged into sewers were used for emission calculations. The BOD from industries assumed that are co-discharged with domestic wastewater in urban high and low income group by expert judgment, therefore were chosen default values as a 1.25 for urban high and low income group, and 1 for rural area for emission calculations.

The methane producing potential (B_0) is the maximum amount of CH_4 that can be produced from a given quantity of organics (as expressed in BOD) in the wastewater. The CH_4 producing potential varies according to the composition of the wastewater and its degradability. The IPCC default value of 0.6 kg CH_4/kg BOD was used for emission calculations.

The Water Supply And Sewerage Authority of Ulaanbaatar City (USUG) manages the centralized system that serves the apartment area and a very small proportion of the ger areas. The main water treatment plant is the central wastewater treatment plant which has a capacity of 170,000 m^3 per day. The volume of wastewater now far exceeds the physical and technical capacity of these plants which have obsolete technical equipment dating from the socialist era. As a result 165,000 to 210,000 m^3 of improperly treated wastewater is discharged into the Tuul River daily. As reported above, 2/3 of the total urban population lives in Ulaanbaatar. Therefore methane correction factor for centralized aerobic treatment plant default IPCC value as 0.3 was used for emission calculations.

Methane conversion factors (MCFs) were applied depending on treatment type and level. The IPCC default values were used as source of MCF value. However, expert judgment was performed to choose values applicable for Mongolian conditions (Table 7-14).

Table 7-14: MCF values applied depending on type and level of treatment

Type of treatment or discharge	*Maximum Methane Producing Capacity, B_0*	*Methane Correction Factor, MCF_j*	*Emission Factor, EF_j*
	(kg CH_4/kg BOD)	*(-)*	*(kg CH_4/kg BOD)*
Centralized aerobic treatment plant	0.6	0.3	0.18
Latrine	0.6	0.1	0.06
Septic system	0.6	0.5	0.3

In Mongolian case, even in the capital city and other main cities, wastewater treatment facilities do not have operational device for the methane recovery or gas combustion in as flare for energy. Originally, at the centralized aerobic treatment plants of big cities including Ulaanbaatar city has installed methane recovery devices and those are never used due to the lack of human capacity and later all of them became out of use (Namkhainyam B. et al, 2014).

Therefore for amount of the methane recovered default IPCC value as zero was used for emission calculations.

N_2O emissions

Due to lack of national research results in order to use country specific activity data and emission factors, the 2006 IPCC GLs default values were used in calculations. The default values for N_2O emission calculations are reported in Table 7-15.

Table 7-15: Emission factors and parameters used in calculations

Activity data and emission factor	*Default value*	*Reference*
F_{NRP}	0.16	2006 IPCC GLs, Vol 5, Ch.6, Table 6.11
$F_{NON-CON}$	1.4	2006 IPCC GLs, Vol 5, Ch.6, Table 6.11
$F_{IND-COM}$	1.25	2006 IPCC GLs, Vol 5, Ch.6, Table 6.11
$EF_{EFFLUENT}$	0.005	2006 IPCC GLs, Vol 5, Ch.6, Table 6.11
N_{SLUDGE}	0	2006 IPCC GLs, Vol 5, Ch.6, page. 6.25
R	0	2006 IPCC GLs, Vol 5, Ch.6, page. 6.9

7.5.1.2.4 Source specific uncertainties and time series consistency

Uncertainty of emission estimates from Wastewater treatment and discharge arises from uncertainties in activity data and emission factors. For the purposes of uncertainty estimation, emissions from domestic wastewater sources of CH_4 and N_2O were separately calculated. The IPCC recommended default values were used as the source of uncertainty values and it is taken from the 2006 IPCC GLs, Vol. 5, Ch. 3, Table 6.7. However, an expert judgment was performed to choose values applicable for GHG emission calculations from this subcategory which are presented in Table 7-16. The time series was checked for consistency.

Table 7-16: Uncertainties in Domestic wastewater treatment and discharge

Input	*Uncertainties*
CH_4 emissions from Domestic wastewater treatment and discharge	
Activity data	
Human Population	±5%
BOD per person	±30%
Fraction of population income group	±15%
Degree of utilization of treatment/discharge pathway or system for each income group	±50%
Correction factor for additional industrial BOD discharged into sewers (I)	±20%
Emission factor	
To centralized aerobic treatment plant, latrines	±10%; ±50%
Maximum Methane Producing Capacity (Bo)	±30%
N_2O emissions from Domestic wastewater treatment and discharge	
Activity data	
Human Population	±10%
Protein	±10%
F_{NRP} (kg N/year)	0.16 (0.15-0.17)

$F_{NON\text{-}CON}$ $F_{IND\text{-}COM}$	1.4 (1.0-1.05) 1.25 (1.0-1.5)
Emission factor	
$E_{EFFLUENT}$ (kg N_2O-N/kg-N)	0.005 (0.0005-0.25)

7.5.1.3 Category-specific recalculations

There have been no recalculations of emissions from this category.

7.5.1.4 Category-specific planned improvements

Since this category is not identified as a key category, improvement is not prioritized.

7.5.2 Industrial Wastewater Treatment and Discharge

7.5.2.1 Category description

The GHG emissions from the Industrial wastewater treatment and discharge have increased by 12.36 Gg CO_2e (146.19%) from the 1990 level of 8.46 Gg CO_2e. The total CO_2e emissions from this subcategory sector in 2020 decreased 3.94% compared with 2019, due to a decrease in alcohol and vegetable oil production. CH_4 emissions from Industrial wastewater treatment for the period 1990-2020 are shown in Figure 7-8.

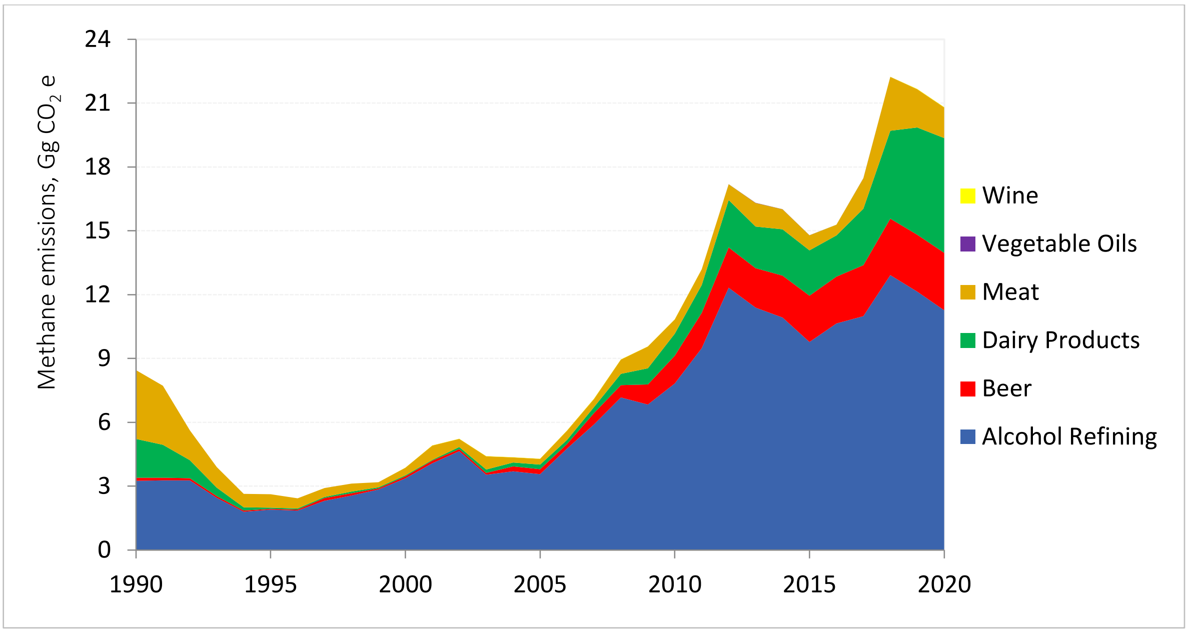

Figure 7-8: CH_4 emissions from industrial wastewater treatment, by industrial outputs, Gg CO_2e

Fluctuations in aggregated methane emissions from Industrial wastewater treatment and discharge could be explained by changes of economic situation. Meanwhile, some industry sectors were almost closed in the middle of 1990s. Since 2012 emissions have been reduced due to the closure of some light industries.

7.5.2.2 Methodological issues

7.5.2.2.1 Choice of method

CH_4 Emissions

The CH_4 emissions from industrial wastewater have been calculated using the IPCC Tier 1 methodology proposed by the 2006 IPCC GLs.

7.5.2.2.2 Activity data

Assessment of CH_4 production potential from industrial wastewater streams is based on the concentration of degradable organic matter in the wastewater which is a chemical oxygen demand (COD), the volume of wastewater, industrial sectors and ways of wastewater treatment. Data on industrial output for industries with the largest potential for wastewater methane emissions identified as follows:

- meat processing (slaughterhouse)
- alcohol production
- beer production
- dairy products
- wine production
- vegetable oil production.

Data on industrial output were taken from a dataset of NSO, for the period 1990-2020. The missing data were assessed by interpolation/extrapolation method. Some industrial outputs were reported in cubic meters, therefore converted units from cubic meters to tonnes by using the density of alcohol, wine, beer, dairy products were taken as 0.789 kg/l, 0.9983 kg/l, 1.01 kg/l, 1.028 kg/l, respectively.

The data of degradable organic component and wastewater produced for per ton production of those industries as a country specific value were taken from the 2006 IPCC GLs and other sources. The above values are presented in the Table 7-17, which was used for entire period of 1990-2020.

Table 7-17: Wastewater generation coefficient and COD concentration according to industrial product

Industry type	*Wastewater generation W, (m^3/t)*	*COD (kg/m^3)*	*Reference*
Alcohol	24.0	11.0	IPCC 2006, Vol. 5, Table 6.9, p 6.22
Beer	6.3	2.9	IPCC 2006, Vol. 5, Table 6.9, p 6.22
Dairy products	7.0	2.7	IPCC 2006, Vol. 5, Table 6.9, p 6.22
Wine	23.0	1.5	IPCC 2006, Vol. 5, Table 6.9, p 6.22
Vegetable oils	3.2	0.8*	IPCC 2006, Vol. 5, Table 6.9, p 6.22
Meat	13.0	4.1	IPCC 2006, Vol. 5, Table 6.9, p 6.22

**-IPCC default value is unavailable. Therefore COD for vegetable oils were taken from Russian NIR-2015 due to same technologies for this product.*

The wastewater production was estimated by multiplying the industrial production by the wastewater generation coefficients. Total organically degradable material was estimated by multiplying the wastewater production by the wastewater generated by the COD coefficient of each industrial product.

The total organically degradable material in industrial wastewater (total organic product TOW) is presented in Table 7-18.

Table 7-18: Total organic product TOW in t/COD/yr

Year	Alcohol	Beer	Dairy Products	Meat	Vegetable Oils	Wine	Total
1990	2,064.63	92.26	1,157.98	3,080.74	-	-	6,395.61
1991	2,078.56	78.62	983.12	2,643.68	-	-	5,783.98
1992	2,078.13	64.98	538.19	1,337.83	-	-	4,019.13
1993	1,556.03	51.34	252.58	922.09	-	-	2,782.04
1994	1,141.69	37.69	95.20	602.29	-	-	1,876.88
1995	1,204.72	24.05	34.97	602.29	-	-	1,866.04
1996	1,176.62	31.23	33.03	453.05	-	-	1,693.93
1997	1,469.19	83.52	31.09	399.75	-	-	1,983.55
1998	1,626.29	67.28	50.52	357.11	-	-	2,101.20
1999	1,805.45	34.19	31.09	229.19	-	-	2,099.91
2000	2,138.53	59.92	29.14	341.12	-	4.31	2,573.03
2001	2,588.51	78.75	23.32	639.60	-	5.65	3,335.83
2002	2,949.80	62.28	62.17	362.44	-	6.09	3,442.79
2003	2,245.37	55.87	101.03	591.63	-	5.89	2,999.79
2004	2,349.27	147.27	114.63	229.19	-	6.17	2,846.52
2005	2,263.53	147.56	137.95	255.84	-	6.33	2,811.22
2006	3,026.27	136.42	120.46	415.74	-	7.71	3,706.60
2007	3,746.27	339.12	178.75	362.44	-	11.28	4,637.85
2008	4,553.29	367.04	336.13	639.60	-	6.77	5,902.83
2009	4,341.64	598.70	481.84	975.39	-	3.74	6,401.32
2010	4,969.71	828.13	656.71	639.60	-	5.06	7,099.21
2011	6,022.61	1,054.27	829.63	703.56	-	4.23	8,614.29
2012	7,826.91	1,201.72	1,414.45	703.56	4.63	2.75	11,154.02
2013	7,232.96	1,176.83	1,241.53	1,053.15	7.32	2.70	10,714.48
2014	6,937.79	1,250.00	1,381.42	894.60	4.51	2.64	10,470.96
2015	6,207.32	1,381.32	1,352.95	671.57	3.90	2.58	9,619.65
2016	6,760.41	1,397.47	1,229.58	477.03	1.68	2.74	9,868.91
2017	6,978.29	1,520.78	1,683.35	1,361.18	5.82	3.53	11,552.96
2018	8,203.51	1,683.74	2,622.90	2,410.32	1.20	3.80	14,925.46
2019	7,710.51	1,697.19	3,200.38	1,710.95	0.65	9.70	14,329.38
2020	7,154.78	1,712.45	3,423.91	1,373.22	0.04	10.34	13,674.74
Diff. % 1990/2020	246.54	1,756.11	195.68	-55.43	-	-	113.81
Diff. % 2019/2020	-7.21	0.90	6.98	-19.74	-93.48	6.64	-4.57

7.5.2.2.3 Emission factors and other parameters

The main meat processing factory uses a septic tank + lagoon system for its wastewater treatment while the alcohol, beer and dairy production industry directly discharges into the central sewer systems with aerobic treatment. Default MCF and EF values obtained from the 2006 IPCC GLs were used for calculations are presented in the Table 7-19.

Table 7-19: Emission factors and parameters used in calculations

Type of treatment or discharge	*Maximum Methane Producing Capacity, B_0*	*Methane Correction Factor, MCF_j*	*Emission Factor, EF_j*
	(kg CH_4/kg COD)	*(-)*	*(kg CH_4/kg COD)*
Aerobic treatment plant	0.25	0.3	0.075
Anaerobic shallow lagoon	0.25	0.2	0.050

7.5.2.2.4 Source specific uncertainties and time series consistency

Uncertainty of the methane emission estimates of industrial wastewater treatment and discharge arises from uncertainties in activity data and emission factors. The IPCC recommended default values were used as the source of uncertainty values and taken from the 2006 IPCC GLs, Vol. 5, Ch. 3, Table 6.10. The 2006 IPCC GLs recommended default values were used as the source of uncertainty values. However, an expert judgment was performed to choose values applicable for the GHG emission calculations from this subcategory which are presented in Table 7-20. The time series was checked for consistency.

Table 7-20: Uncertainties in Industrial wastewater treatment and discharge

Input	*Uncertainties*
CH_4 emissions from Industrial wastewater treatment and discharge	
Activity data	
Industrial Production	±5%
Wastewater /unit production COD/unit wastewater	±50%
Emission factor	
Methane correction factor (MCF)	±30%
Maximum Methane Producing Capacity (B_0)	±30%

7.5.2.3 Category-specific recalculations

There have been no recalculations of emissions from this category.

7.5.2.4 Category-specific planned improvements

All activity data and parameters of Wastewater treatment plant and discharge for the emissions estimations will be kept under investigation and updated when the data become available, will consider using them in the calculation of the emissions.

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Annex I: Summary tables

Inventory Year: 1990

	Emissions (Gg)			Emissions CO_2 equivalents (Gg)					Emissions (Gg)			
Categories	*Net CO_2 (1)(2)*	*CH_4*	*N_2O*	*HFCs*	*PFCs*	*SF_6*	*Other halogenated gases with CO_2 equivalent conversion factors (3)*	*Other halogenated gases without CO_2 equivalent conversion factors (4)*	*NOx*	*CO*	*NMVOCs*	*SO_2*
Total National Emissions and Removals	-17,056.64	337.00	14.84	0	0	0	0	0	22.84	422.31	0	0
1 - Energy	11,685.58	10.47	0.58	0	0	0	0	0	0	0	0	0
1.A - Fuel Combustion Activities	11,685.58	4.24	0.58	0	0	0	0	0	0	0	0	0
1.A.1 - Energy Industries	6,374.34	0.12	0.10						0	0	0	0
1.A.2 - Manufacturing Industries and Construction	1,483.22	0.17	0.02						0	0	0	0
1.A.3 - Transport	2,139.48	0.41	0.42						0	0	0	0
1.A.4 - Other Sectors	1,015.44	3.54	0.03						0	0	0	0
1.A.5 - Non-Specified	673.10	0.01	0.01						0	0	0	0
1.B - Fugitive emissions from fuels	0	6.23	0	0	0	0	0	0	0	0	0	0
1.B.1 - Solid Fuels	0	6.23	0						0	0	0	0
1.B.2 - Oil and Natural Gas	0	0	0						0	0	0	0
1.B.3 - Other emissions from Energy Production	0	0	0						0	0	0	0
1.C - Carbon dioxide Transport and Storage	0	0	0	0	0	0	0	0	0	0	0	0
1.C.1 - Transport of CO_2	0								0	0	0	0
1.C.2 - Injection and Storage	0								0	0	0	0
1.C.3 - Other	0								0	0	0	0
2 - Industrial Processes and Product Use	284.98	0	0	0	0	0	0	0	0	0	0	0
2.A - Mineral Industry	272.08	0	0	0	0	0	0	0	0	0	0	0
2.A.1 - Cement production	194.83								0	0	0	0
2.A.2 - Lime production	77.25								0	0	0	0
2.A.3 - Glass Production	0								0	0	0	0
2.A.4 - Other Process Uses of Carbonates	0								0	0	0	0
2.A.5 - Other (please specify)	0	0	0						0	0	0	0
2.B - Chemical Industry	0	0	0	0	0	0	0	0	0	0	0	0
2.B.1 - Ammonia Production	0								0	0	0	0

2.B.2 - Nitric Acid Production			0						0	0	0	0
2.B.3 - Adipic Acid Production			0						0	0	0	0
2.B.4 - Caprolactam. Glyoxal and Glyoxylic Acid Production			0						0	0	0	0
2.B.5 - Carbide Production	0	0							0	0	0	0
2.B.6 - Titanium Dioxide Production	0								0	0	0	0
2.B.7 - Soda Ash Production	0								0	0	0	0
2.B.8 - Petrochemical and Carbon Black Production	0	0							0	0	0	0
2.B.9 - Fluorochemical Production				0	0	0	0	0	0	0	0	0
2.B.10 - Other (Please specify)	0	0	0	0	0	0	0	0	0	0	0	0
2.C - Metal Industry	0	0	0	0	0	0	0	0	0	0	0	0
2.C.1 - Iron and Steel Production	0	0							0	0	0	0
2.C.2 - Ferroalloys Production	0	0							0	0	0	0
2.C.3 - Aluminium production	0				0			0	0	0	0	0
2.C.4 - Magnesium production	0					0		0	0	0	0	0
2.C.5 - Lead Production	0								0	0	0	0
2.C.6 - Zinc Production	0								0	0	0	0
2.C.7 - Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0
2.D - Non-Energy Products from Fuels and Solvent Use	12.89	0	0	0	0	0	0	0	0	0	0	0
2.D.1 - Lubricant Use	12.89								0	0	0	0
2.D.2 - Paraffin Wax Use	0								0	0	0	0
2.D.3 - Solvent Use									0	0	0	0
2.D.4 - Other (please specify)	0	0	0						0	0	0	0
2.E - Electronics Industry	0	0	0	0	0	0	0	0	0	0	0	0
2.E.1 - Integrated Circuit or Semiconductor				0	0	0	0	0	0	0	0	0
2.E.2 - TFT Flat Panel Display					0	0	0	0	0	0	0	0
2.E.3 - Photovoltaics					0			0	0	0	0	0
2.E.4 - Heat Transfer Fluid					0			0	0	0	0	0
2.E.5 - Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0	0	0	0	0	0	0	0	0	0	0	0
2.F.1 - Refrigeration and Air Conditioning				0				0	0	0	0	0
2.F.2 - Foam Blowing Agents				0				0	0	0	0	0
2.F.3 - Fire Protection				0	0			0	0	0	0	0
2.F.4 - Aerosols				0				0	0	0	0	0
2.F.5 - Solvents				0	0			0	0	0	0	0

2.F.6 - Other Applications (please specify)				0	0			0	0	0	0	0
2.G - Other Product Manufacture and Use	0	0	0	0	0	0	0	0	0	0	0	0
2.G.1 - Electrical Equipment					0	0		0	0	0	0	0
2.G.2 - SF_6 and PFCs from Other Product Uses					0	0		0	0	0	0	0
2.G.3 - N_2O from Product Uses			0						0	0	0	0
2.G.4 - Other (Please specify)	0	0	0	0	0	0	0	0	0	0	0	0
2.H - Other	0	0	0	0	0	0	0	0	0	0	0	0
2.H.1 - Pulp and Paper Industry	0	0							0	0	0	0
2.H.2 - Food and Beverages Industry	0	0							0	0	0	0
2.H.3 - Other (please specify)	0	0	0						0	0	0	0
3 - Agriculture. Forestry. and Other Land Use	-29,027.19	324.46	14.22	0	0	0	0	0	22.84	422.31	0	0
3.A - Livestock	0	308.85	0	0	0	0	0	0	0	0	0	0
3.A.1 - Enteric Fermentation		300.51							0	0	0	0
3.A.2 - Manure Management		8.34	0						0	0	0	0
3.B - Land	-28,944.49	0	0	0	0	0	0	0	0	0	0	0
3.B.1 - Forest land	-29,367.35								0	0	0	0
3.B.2 - Cropland	0.00								0	0	0	0
3.B.3 - Grassland	422.86								0	0	0	0
3.B.4 - Wetlands	0.00		0						0	0	0	0
3.B.5 - Settlements	0.00								0	0	0	0
3.B.6 - Other Land	0.00								0	0	0	0
3.C - Aggregate sources and non-CO_2 emissions sources on land	0	15.61	14.22	0	0	0	0	0	22.84	422.31	0	0
3.C.1 - Emissions from biomass burning		15.61	1.30						22.8 4	422.31	0	0
3.C.2 - Liming	0								0	0	0	0
3.C.3 - Urea application	0								0	0	0	0
3.C.4 - Direct N_2O Emissions from managed soils			9.63						0	0	0	0
3.C.5 - Indirect N_2O Emissions from managed soils			3.29						0	0	0	0
3.C.6 - Indirect N_2O Emissions from manure management			0						0	0	0	0
3.C.7 - Rice cultivations		0							0	0	0	0
3.C.8 - Other (please specify)		0	0						0	0	0	0
3.D - Other	-82.70	0	0	0	0	0	0	0	0	0	0	0
3.D.1 - Harvested Wood Products	-82.70								0	0	0	0
3.D.2 - Other (please specify)	0	0	0						0	0	0	0
4 - Waste	0	2.06	0.04	0	0	0	0	0	0	0	0	0

4.A - Solid Waste Disposal	0	0.73	0	0	0	0	0	0	0	0	0	0
4.B - Biological Treatment of Solid Waste	0	0	0	0	0	0	0	0	0	0	0	0
4.C - Incineration and Open Burning of Waste	0	0	0	0	0	0	0	0	0	0	0	0
4.D - Wastewater Treatment and Discharge	0	1.33	0.04	0	0	0	0	0	0	0	0	0
4.E - Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0
5 - Other	0	0	0	0	0	0	0	0	0	0	0	0
5.A - Indirect N_2O emissions from the atmospheric deposition of nitrogen in NOx and NH_3	0	0	0	0	0	0	0	0	0	0	0	0
5.B - Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0
Memo Items (5)												
International Bunkers	5.97	0.00	0.00	0	0	0	0	0	0	0	0	0
1.A.3.a.i - International Aviation (International Bunkers)	5.97	0.00	0.00						0	0	0	0
1.A.3.d.i - International water-borne navigation (International bunkers)	0	0	0						0	0	0	0
1.A.5.c - Multilateral Operations	0	0	0	0	0	0	0	0	0	0	0	0

Inventory Year: 2020

	Emissions (Gg)			Emissions CO_2 equivalents (Gg)				Emissions (Gg)				
Categories	*Net CO_2 (1)(2)*	*CH_4*	*N_2O*	*HFCs*	*PFCs*	*SF_6*	*Other halogenated gases with CO_2 equivalent conversion factors (3)*	*Other halogenated gases without CO_2 equivalent conversion factors (4)*	*NOx*	*CO*	*NMVOCs*	*SO_2*
Total National Emissions and Removals	-11,906.87	693.83	31.21	571.30	0	0	0	0.00	3.36	83.58	0	0
1 - Energy	17,689.21	57.16	1.30	0	0	0	0	0	0	0	0	0
1.A - Fuel Combustion Activities	17,656.40	4.67	1.30	0	0	0	0	0	0	0	0	0
1.A.1 - Energy Industries	11,033.07	0.23	0.19						0	0	0	0
1.A.2 - Manufacturing Industries and Construction	295.07	0.03	0.00						0	0	0	0
1.A.3 - Transport	4,555.80	0.77	1.05						0	0	0	0
1.A.4 - Other Sectors	874.15	3.62	0.04						0	0	0	0
1.A.5 - Non-Specified	898.31	0.01	0.02						0	0	0	0
1.B - Fugitive emissions from fuels	32.81	52.50	0.00	0	0	0	0	0	0	0	0	0
1.B.1 - Solid Fuels	0	32.99	0						0	0	0	0
1.B.2 - Oil and Natural Gas	32.81	19.51	0						0	0	0	0
1.B.3 - Other emissions from Energy Production	0	0	0						0	0	0	0
1.C - Carbon dioxide Transport and Storage	0	0	0	0	0	0	0	0	0	0	0	0
1.C.1 - Transport of CO_2	0								0	0	0	0
1.C.2 - Injection and Storage	0								0	0	0	0
1.C.3 - Other	0								0	0	0	0
2 - Industrial Processes and Product Use	576.45	0	0	571.30	0	0	0	0.00	0	0	0	0
2.A - Mineral Industry	575.18	0	0	0	0	0	0	0	0	0	0	0
2.A.1 - Cement production	522.53								0	0	0	0
2.A.2 - Lime production	52.65								0	0	0	0
2.A.3 - Glass Production	0								0	0	0	0
2.A.4 - Other Process Uses of Carbonates	0								0	0	0	0
2.A.5 - Other (please specify)	0	0	0						0	0	0	0
2.B - Chemical Industry	0	0	0	0	0	0	0	0	0	0	0	0
2.B.1 - Ammonia Production	0								0	0	0	0
2.B.2 - Nitric Acid Production			0						0	0	0	0
2.B.3 - Adipic Acid Production			0						0	0	0	0

2.B.4 - Caprolactam. Glyoxal and Glyoxylic Acid Production			0						0	0	0	0
2.B.5 - Carbide Production	0	0							0	0	0	0
2.B.6 - Titanium Dioxide Production	0								0	0	0	0
2.B.7 - Soda Ash Production	0								0	0	0	0
2.B.8 - Petrochemical and Carbon Black Production	0	0							0	0	0	0
2.B.9 - Fluorochemical Production				0	0	0	0	0	0	0	0	0
2.B.10 - Other (Please specify)	0	0	0	0	0	0	0	0	0	0	0	0
2.C - Metal Industry	1.22	0	0	0	0	0	0	0	0	0	0	0
2.C.1 - Iron and Steel Production	1.22	0							0	0	0	0
2.C.2 - Ferroalloys Production	0	0							0	0	0	0
2.C.3 - Aluminium production	0				0			0	0	0	0	0
2.C.4 - Magnesium production	0					0		0	0	0	0	0
2.C.5 - Lead Production	0								0	0	0	0
2.C.6 - Zinc Production	0								0	0	0	0
2.C.7 - Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0
2.D - Non-Energy Products from Fuels and Solvent Use	0.04	0	0	0	0	0	0	0	0	0	0	0
2.D.1 - Lubricant Use	0.04								0	0	0	0
2.D.2 - Paraffin Wax Use	0								0	0	0	0
2.D.3 - Solvent Use									0	0	0	0
2.D.4 - Other (please specify)	0	0	0						0	0	0	0
2.E - Electronics Industry	0	0	0	0	0	0	0	0	0	0	0	0
2.E.1 - Integrated Circuit or Semiconductor				0	0	0	0	0	0	0	0	0
2.E.2 - TFT Flat Panel Display					0	0	0	0	0	0	0	0
2.E.3 - Photovoltaics					0			0	0	0	0	0
2.E.4 - Heat Transfer Fluid					0			0	0	0	0	0
2.E.5 - Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0	0	0	571.30	0	0	0	0.00	0	0	0	0
2.F.1 - Refrigeration and Air Conditioning				569.28				0	0	0	0	0
2.F.2 - Foam Blowing Agents				1.05				0.00	0	0	0	0
2.F.3 - Fire Protection				0.97	0			0	0	0	0	0
2.F.4 - Aerosols				0				0	0	0	0	0
2.F.5 - Solvents				0	0			0	0	0	0	0
2.F.6 - Other Applications (please specify)				0	0			0	0	0	0	0
2.G - Other Product Manufacture and Use	0	0	0	0	0	0	0	0	0	0	0	0

2.G.1 - Electrical Equipment					0	0		0	0	0	0	0
2.G.2 - SF_6 and PFCs from Other Product Uses					0	0		0	0	0	0	0
2.G.3 - N_2O from Product Uses			0						0	0	0	0
2.G.4 - Other (Please specify)	0	0	0	0	0	0	0	0	0	0	0	0
2.H - Other	0	0	0	0	0	0	0	0	0	0	0	0
2.H.1 - Pulp and Paper Industry	0	0							0	0	0	0
2.H.2 - Food and Beverages Industry	0	0							0	0	0	0
2.H.3 - Other (please specify)	0	0	0						0	0	0	0
3 - Agriculture. Forestry. and Other Land Use	-30,172.52	626.02	29.82	0	0	0	0	0	3.36	83.58	0	0
3.A - Livestock	0	622.63	0	0	0	0	0	0	0	0	0	0
3.A.1 - Enteric Fermentation		606.72							0	0	0	0
3.A.2 - Manure Management		15.90	0						0	0	0	0
3.B - Land	-30,332.02	0	0	0	0	0	0	0	0	0	0	0
3.B.1 - Forest land	-30,336.91								0	0	0	0
3.B.2 - Cropland	0								0	0	0	0
3.B.3 - Grassland	4.89								0	0	0	0
3.B.4 - Wetlands	0		0						0	0	0	0
3.B.5 - Settlements	0								0	0	0	0
3.B.6 - Other Land	0								0	0	0	0
3.C - Aggregate sources and non-CO_2 emissions sources on land	0	3.40	29.82	0	0	0	0	0	3.36	83.58	0	0
3.C.1 - Emissions from biomass burning		3.40	0.23						3.36	83.58	0	0
3.C.2 - Liming	0								0	0	0	0
3.C.3 - Urea application	0								0	0	0	0
3.C.4 - Direct N_2O Emissions from managed soils			21.71						0	0	0	0
3.C.5 - Indirect N_2O Emissions from managed soils			7.88						0	0	0	0
3.C.6 - Indirect N_2O Emissions from manure management			0						0	0	0	0
3.C.7 - Rice cultivations		0							0	0	0	0
3.C.8 - Other (please specify)		0	0						0	0	0	0
3.D - Other	159.50	0	0	0	0	0	0	0	0	0	0	0
3.D.1 - Harvested Wood Products	159.50								0	0	0	0
3.D.2 - Other (please specify)	0	0	0						0	0	0	0
4 - Waste	0	10.65	0.09	0	0	0	0	0	0	0	0	0
4.A - Solid Waste Disposal	0	7.41	0	0	0	0	0	0	0	0	0	0
4.B - Biological Treatment of Solid Waste	0	0	0	0	0	0	0	0	0	0	0	0

4.C - Incineration and Open Burning of Waste	0	0	0	0	0	0	0	0	0	0	0	0
4.D - Wastewater Treatment and Discharge	0	3.23	0.09	0	0	0	0	0	0	0	0	0
4.E - Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0
5 - Other	0	0	0	0	0	0	0	0	0	0	0	0
5.A - Indirect N_2O emissions from the atmospheric deposition of nitrogen in NOx and NH_3	0	0	0	0	0	0	0	0	0	0	0	0
5.B - Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0
Memo Items (5)												
International Bunkers	30.27	0.0002	0.0008	0	0	0	0	0	0	0	0	0
1.A.3.a.i - International Aviation (International Bunkers)	30.27	0.0002	0.0008						0	0	0	0
1.A.3.d.i - International water-borne navigation (International bunkers)	0	0	0						0	0	0	0
1.A.5.c - Multilateral Operations	0	0	0	0	0	0	0	0	0	0	0	0

Annex II: Key category analysis

2020 year Key Category Tier 1 Analysis – Level Assessment, with LULUCF

IPCC Category code	*IPCC Category*	*Greenhouse gas*	*2020 Ex.t (Gg CO_2 e)*	*|Ex.t| (Gg CO_2 e)*	*Lx.t*	*Cumulative Total of Column F*
3.B.1.a	Forest land Remaining Forest land	CO_2	-30,331.06	30,331.06	0.41	0.41
3.A.1	Enteric Fermentation	CH_4	12,741.16	12,741.16	0.17	0.59
1.A.1	Energy Industries - Solid Fuels	CO_2	10,673.99	10,673.99	0.15	0.73
3.C.4	Direct N_2O Emissions from managed soils	N_2O	6,729.39	6,729.39	0.09	0.82
3.C.5	Indirect N_2O Emissions from managed soils	N_2O	2,443.77	2,443.77	0.03	0.86
1.A.3.b	Road Transportation	CO_2	2,375.14	2,375.14	0.03	0.89
1.A.3.e	Other Transportation	CO_2	1,683.49	1,683.49	0.02	0.91
1.A.5	Non-Specified - Solid Fuels	CO_2	898.31	898.31	0.01	0.92
1.A.4	Other Sectors - Solid Fuels	CO_2	823.22	823.22	0.01	0.93
1.B.1	Solid Fuels	CH_4	692.75	692.75	0.01	0.94
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	569.28	569.28	0.01	0.95
2.A.1	Cement production	CO_2	522.53	522.53	0.01	0.96
1.A.3.c	Railways	CO_2	466.90	466.90	0.01	0.96
1.B.2.a	Oil	CH_4	409.66	409.66	0.01	0.97
1.A.1	Energy Industries - Liquid Fuels	CO_2	359.08	359.08	0.00	0.97
3.A.2	Manure Management	CH_4	334.00	334.00	0.00	0.98
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	295.07	295.07	0.00	0.98
1.A.3.e	Other Transportation	N_2O	201.43	201.43	0.00	0.99
3.D.1	Harvested Wood Products	CO_2	159.50	159.50	0.00	0.99
4.A	Solid Waste Disposal	CH_4	155.63	155.63	0.00	0.99
1.A.3.b	Road Transportation	N_2O	71.86	71.86	0.00	0.99
3.C.1	Emissions from biomass burning	CH_4	71.36	71.36	0.00	0.99
3.C.1	Emissions from biomass burning	N_2O	70.89	70.89	0.00	0.99
4.D	Wastewater Treatment and Discharge	CH_4	67.93	67.93	0.00	0.99
1.A.4	Other Sectors - Solid Fuels	CH_4	58.47	58.47	0.00	0.99
2.A.2	Lime production	CO_2	52.65	52.65	0.00	1.00
1.A.1	Energy Industries - Solid Fuels	N_2O	52.18	52.18	0.00	1.00
1.A.3.c	Railways	N_2O	51.39	51.39	0.00	1.00
1.A.4	Other Sectors - Liquid Fuels	CO_2	50.93	50.93	0.00	1.00
1.B.2.a	Oil	CO_2	32.81	32.81	0.00	1.00
1.A.3.a	Civil Aviation	CO_2	30.27	30.27	0.00	1.00

4.D	Wastewater Treatment and Discharge	N_2O	27.27	27.27	0.00	1.00
1.A.4	Other Sectors - Biomass	CH_4	17.52	17.52	0.00	1.00
1.A.3.b	Road Transportation	CH_4	13.63	13.63	0.00	1.00
1.A.4	Other Sectors - Liquid Fuels	N_2O	6.09	6.09	0.00	1.00
3.B.1.b	Land Converted to Forest land	CO_2	-5.85	5.85	0.00	1.00
3.B.3.b	Land Converted to Grassland	CO_2	4.89	4.89	0.00	1.00
1.A.5	Non-Specified - Solid Fuels	N_2O	4.50	4.50	0.00	1.00
1.A.1	Energy Industries - Biomass	N_2O	4.37	4.37	0.00	1.00
1.A.4	Other Sectors - Solid Fuels	N_2O	4.34	4.34	0.00	1.00
1.A.4	Other Sectors - Biomass	N_2O	3.45	3.45	0.00	1.00
1.A.1	Energy Industries - Solid Fuels	CH_4	2.36	2.36	0.00	1.00
1.A.1	Energy Industries - Biomass	CH_4	2.22	2.22	0.00	1.00
1.A.3.e	Other Transportation	CH_4	1.98	1.98	0.00	1.00
1.A.2	Manufacturing Industries and Construction - Solid Fuels	N_2O	1.50	1.50	0.00	1.00
2.C.1	Iron and Steel Production	CO_2	1.22	1.22	0.00	1.00
2.F.2	Foam Blowing Agents	HFCs (HFCs)	1.05	1.05	0.00	1.00
2.F.3	Fire Protection	HFCs, PFCs	0.97	0.97	0.00	1.00
1.A.1	Energy Industries - Liquid Fuels	N_2O	0.90	0.90	0.00	1.00
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CH_4	0.68	0.68	0.00	1.00
1.A.3.c	Railways	CH_4	0.52	0.52	0.00	1.00
1.A.5	Non-Specified - Biomass	N_2O	0.47	0.47	0.00	1.00
1.A.1	Energy Industries - Liquid Fuels	CH_4	0.30	0.30	0.00	1.00
1.A.3.a	Civil Aviation	N_2O	0.26	0.26	0.00	1.00
1.A.5	Non-Specified - Solid Fuels	CH_4	0.20	0.20	0.00	1.00
1.B.2.a	Oil	N_2O	0.15	0.15	0.00	1.00
1.A.4	Other Sectors - Liquid Fuels	CH_4	0.06	0.06	0.00	1.00
2.D	Non-Energy Products from Fuels and Solvent Use	CO_2	0.04	0.04	0.00	1.00
1.A.5	Non-Specified - Biomass	CH_4	0.02	0.02	0.00	1.00
1.A.3.a	Civil Aviation	CH_4	0.00	0.00	0.00	1.00
Total						
			12,909.10	73,582.92	1	

2020 year Key Category Tier 1 Analysis – Trend Assessment, with LULUCF

IPCC Category code	IPCC Category	Greenhouse gas	1990 Year Estimate Ex0 (Gg CO_2 e)	2020 Year Estimate Ext (Gg CO_2 e)	Trend Assessment (Txt)	Contribution to Trend %	Cumulative Total of Column G
3.B.1.a	Forest land Remaining Forest land	CO_2	-29,358.76	-30,331.06	1.88	0.61	0.61
1.A.1	Energy Industries - Solid Fuels	CO_2	6,045.93	10,673.99	0.30	0.10	0.70
3.A.1	Enteric Fermentation	CH_4	6,310.67	12,741.16	0.28	0.09	0.79
3.C.4	Direct N_2O Emissions from managed soils	N_2O	2,984.13	6,729.39	0.12	0.04	0.83
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	1,483.22	295.07	0.12	0.04	0.87
1.A.4	Other Sectors - Solid Fuels	CO_2	997.39	823.22	0.07	0.02	0.89
1.A.3.b	Road Transportation	CO_2	1,228.52	2,375.14	0.06	0.02	0.91
1.A.5	Non-Specified - Solid Fuels	CO_2	673.10	898.31	0.04	0.01	0.92
3.C.5	Indirect N_2O Emissions from managed soils	N_2O	1,020.23	2,443.77	0.04	0.01	0.93
3.B.3.b	Land Converted to Grassland	CO_2	422.86	4.89	0.03	0.01	0.94
3.C.1	Emissions from biomass burning	N_2O	403.58	70.89	0.03	0.01	0.95
3.C.1	Emissions from biomass burning	CH_4	327.81	71.36	0.03	0.01	0.96
1.A.1	Energy Industries - Liquid Fuels	CO_2	328.40	359.08	0.02	0.01	0.97
1.A.3.e	Other Transportation	CO_2	596.75	1,683.49	0.02	0.01	0.98
1.A.3.c	Railways	CO_2	308.25	466.90	0.02	0.01	0.98
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	0.00	569.28	0.01	0.00	0.98
3.A.2	Manure Management	CH_4	175.23	334.00	0.01	0.00	0.99
1.B.2.a	Oil	CH_4	0.00	409.66	0.01	0.00	0.99
2.A.1	Cement production	CO_2	194.83	522.53	0.01	0.00	0.99
2.A.2	Lime production	CO_2	77.25	52.65	0.01	0.00	0.99
1.A.4	Other Sectors - Solid Fuels	CH_4	65.69	58.47	0.00	0.00	0.99
1.B.1	Solid Fuels	CH_4	130.91	692.75	0.00	0.00	1.00
1.A.3.e	Other Transportation	N_2O	71.40	201.43	0.00	0.00	1.00
1.A.3.b	Road Transportation	N_2O	39.31	71.86	0.00	0.00	1.00
4.A	Solid Waste Disposal	CH_4	15.33	155.63	0.00	0.00	1.00
1.A.1	Energy Industries - Solid Fuels	N_2O	28.95	52.18	0.00	0.00	1.00
2.D	Non-Energy Products from Fuels and Solvent Use	CO_2	12.89	0.04	0.00	0.00	1.00

4.D	Wastewater Treatment and Discharge	CH_4	27.90	67.93	0.00	0.00	1.00
3.D.1	Harvested Wood Products	CO_2	-82.70	159.50	0.00	0.00	1.00
1.B.2.a	Oil	CO_2	0.00	32.81	0.00	0.00	1.00
1.A.2	Manufacturing Industries and Construction - Solid Fuels	N_2O	7.69	1.50	0.00	0.00	1.00
1.A.3.c	Railways	N_2O	18.91	51.39	0.00	0.00	1.00
1.A.4	Other Sectors - Liquid Fuels	CO_2	18.05	50.93	0.00	0.00	1.00
4.D	Wastewater Treatment and Discharge	N_2O	12.39	27.27	0.00	0.00	1.00
3.B.1.b	Land Converted to Forest land	CO_2	-8.59	-5.85	0.00	0.00	1.00
1.A.3.b	Road Transportation	CH_4	7.76	13.63	0.00	0.00	1.00
1.A.4	Other Sectors - Biomass	CH_4	8.57	17.52	0.00	0.00	1.00
1.A.4	Other Sectors - Solid Fuels	N_2O	4.86	4.34	0.00	0.00	1.00
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CH_4	3.47	0.68	0.00	0.00	1.00
1.A.5	Non-Specified - Solid Fuels	N_2O	3.28	4.50	0.00	0.00	1.00
1.A.3.a	Civil Aviation	CO_2	5.97	30.27	0.00	0.00	1.00
1.A.4	Other Sectors - Biomass	N_2O	1.69	3.45	0.00	0.00	1.00
1.A.4	Other Sectors - Liquid Fuels	N_2O	2.16	6.09	0.00	0.00	1.00
1.A.1	Energy Industries - Solid Fuels	CH_4	1.31	2.36	0.00	0.00	1.00
1.A.1	Energy Industries - Biomass	N_2O	1.68	4.37	0.00	0.00	1.00
1.A.1	Energy Industries - Liquid Fuels	N_2O	0.80	0.90	0.00	0.00	1.00
1.A.1	Energy Industries - Biomass	CH_4	0.85	2.22	0.00	0.00	1.00
2.C.1	Iron and Steel Production	CO_2	0.00	1.22	0.00	0.00	1.00
1.A.3.e	Other Transportation	CH_4	0.70	1.98	0.00	0.00	1.00
2.F.2	Foam Blowing Agents	HFCs, PFCs	0.00	1.05	0.00	0.00	1.00
2.F.3	Fire Protection	HFCs, PFCs	0.00	0.97	0.00	0.00	1.00
1.A.1	Energy Industries - Liquid Fuels	CH_4	0.27	0.30	0.00	0.00	1.00
1.A.3.c	Railways	CH_4	0.25	0.52	0.00	0.00	1.00
1.A.5	Non-Specified - Biomass	N_2O	0.23	0.47	0.00	0.00	1.00
1.A.5	Non-Specified - Solid Fuels	CH_4	0.15	0.20	0.00	0.00	1.00
1.B.2.a	Oil	N_2O	0.00	0.15	0.00	0.00	1.00
1.A.3.a	Civil Aviation	N_2O	0.05	0.26	0.00	0.00	1.00

1.A.4	Other Sectors - Liquid Fuels	CH_4	0.02	0.06	0.00	0.00		1.00
1.A.5	Non-Specified - Biomass	CH_4	0.01	0.02	0.00	0.00		1.00
1.A.3.a	Civil Aviation	CH_4	0.00	0.00	0.00	0.00		1.00
Total								
			-5,378.40	12,909.10	3.10	1		

2020 year Key Category Tier 1 Analysis – Level Assessment, without LULUCF

IPCC Category code	*IPCC Category*	*Greenhouse gas*	*2020 Ex.t (Gg CO_2 e)*	*|Ex.t| (Gg CO_2 e)*	*Lx.t*	*Cumulative Total of Column F*
3.A.1	Enteric Fermentation	CH_4	12,741.16	12,741.16	0.30	0.30
1.A.1	Energy Industries - Solid Fuels	CO_2	10,673.99	10,673.99	0.25	0.54
3.C.4	Direct N_2O Emissions from managed soils	N_2O	6,729.39	6,729.39	0.16	0.70
3.C.5	Indirect N_2O Emissions from managed soils	N_2O	2,443.77	2,443.77	0.06	0.76
1.A.3.b	Road Transportation	CO_2	2,375.14	2,375.14	0.06	0.81
1.A.3.e	Other Transportation	CO_2	1,683.49	1,683.49	0.04	0.85
1.A.5	Non-Specified - Solid Fuels	CO_2	898.31	898.31	0.02	0.87
1.A.4	Other Sectors - Solid Fuels	CO_2	823.22	823.22	0.02	0.89
1.B.1	Solid Fuels	CH_4	692.75	692.75	0.02	0.91
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	569.28	569.28	0.01	0.92
2.A.1	Cement production	CO_2	522.53	522.53	0.01	0.93
1.A.3.c	Railways	CO_2	466.90	466.90	0.01	0.94
1.B.2.a	Oil	CH_4	409.66	409.66	0.01	0.95
1.A.1	Energy Industries - Liquid Fuels	CO_2	359.08	359.08	0.01	0.96
3.A.2	Manure Management	CH_4	334.00	334.00	0.01	0.97
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	295.07	295.07	0.01	0.98
1.A.3.e	Other Transportation	N_2O	201.43	201.43	0.00	0.98
4.A	Solid Waste Disposal	CH_4	155.63	155.63	0.00	0.98
1.A.3.b	Road Transportation	N_2O	71.86	71.86	0.00	0.99
3.C.1	Emissions from biomass burning	CH_4	71.36	71.36	0.00	0.99
3.C.1	Emissions from biomass burning	N_2O	70.89	70.89	0.00	0.99
4.D	Wastewater Treatment and Discharge	CH_4	67.93	67.93	0.00	0.99
1.A.4	Other Sectors - Solid Fuels	CH_4	58.47	58.47	0.00	0.99
2.A.2	Lime production	CO_2	52.65	52.65	0.00	0.99
1.A.1	Energy Industries - Solid Fuels	N_2O	52.18	52.18	0.00	0.99

1.A.3.c	Railways	N_2O	51.39	51.39	0.00	1.00
1.A.4	Other Sectors - Liquid Fuels	CO_2	50.93	50.93	0.00	1.00
1.B.2.a	Oil	CO_2	32.81	32.81	0.00	1.00
1.A.3.a	Civil Aviation	CO_2	30.27	30.27	0.00	1.00
4.D	Wastewater Treatment and Discharge	N_2O	27.27	27.27	0.00	1.00
1.A.4	Other Sectors - Biomass	CH_4	17.52	17.52	0.00	1.00
1.A.3.b	Road Transportation	CH_4	13.63	13.63	0.00	1.00
1.A.4	Other Sectors - Liquid Fuels	N_2O	6.09	6.09	0.00	1.00
1.A.5	Non-Specified - Solid Fuels	N_2O	4.50	4.50	0.00	1.00
1.A.1	Energy Industries - Biomass	N_2O	4.37	4.37	0.00	1.00
1.A.4	Other Sectors - Solid Fuels	N_2O	4.34	4.34	0.00	1.00
1.A.4	Other Sectors - Biomass	N_2O	3.45	3.45	0.00	1.00
1.A.1	Energy Industries - Solid Fuels	CH_4	2.36	2.36	0.00	1.00
1.A.1	Energy Industries - Biomass	CH_4	2.22	2.22	0.00	1.00
1.A.3.e	Other Transportation	CH_4	1.98	1.98	0.00	1.00
1.A.2	Manufacturing Industries and Construction - Solid Fuels	N_2O	1.50	1.50	0.00	1.00
2.C.1	Iron and Steel Production	CO_2	1.22	1.22	0.00	1.00
2.F.2	Foam Blowing Agents	HFCs	1.05	1.05	0.00	1.00
2.F.3	Fire Protection	(HFCs) HFCs, PFCs	0.97	0.97	0.00	1.00
1.A.1	Energy Industries - Liquid Fuels	N_2O	0.90	0.90	0.00	1.00
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CH_4	0.68	0.68	0.00	1.00
1.A.3.c	Railways	CH_4	0.52	0.52	0.00	1.00
1.A.5	Non-Specified - Biomass	N_2O	0.47	0.47	0.00	1.00
1.A.1	Energy Industries - Liquid Fuels	CH_4	0.30	0.30	0.00	1.00
1.A.3.a	Civil Aviation	N_2O	0.26	0.26	0.00	1.00
1.A.5	Non-Specified - Solid Fuels	CH_4	0.20	0.20	0.00	1.00
1.B.2.a	Oil	N_2O	0.15	0.15	0.00	1.00
1.A.4	Other Sectors - Liquid Fuels	CH_4	0.06	0.06	0.00	1.00
2.D	Non-Energy Products from Fuels and Solvent Use	CO_2	0.04	0.04	0.00	1.00
1.A.5	Non-Specified - Biomass	CH_4	0.02	0.02	0.00	1.00
1.A.3.a	Civil Aviation	CH_4	0.00	0.00	0.00	1.00
Total						
			43,081.62	43,081.62	1	

2020 year Key Category Tier 1 Analysis – Trend Assessment, without LULUCF

IPCC Category code	*IPCC Category*	*Greenhouse gas*	*1990 Year Estimate Ex0 (Gg CO_2 Eq)*	*2020 Year Estimate Ext (Gg CO_2 Eq)*	*Trend Assessment (Txt)*	*Contribution to Trend %*	*Cumulative Total of Column G*
1.A.1	Energy Industries - Solid Fuels	CO_2	6,045.93	10,673.99	0.01	0.03	0.03
3.A.1	Enteric Fermentation	CH_4	6,310.67	12,741.16	0.05	0.11	0.14
3.C.4	Direct N_2O Emissions from managed soils	N_2O	2,984.13	6,729.39	0.05	0.11	0.25
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	1,483.22	295.07	0.10	0.21	0.46
1.A.4	Other Sectors - Solid Fuels	CO_2	997.39	823.22	0.04	0.09	0.54
1.A.3.b	Road Transportation	CO_2	1,228.52	2,375.14	0.01	0.01	0.55
1.A.5	Non-Specified - Solid Fuels	CO_2	673.10	898.31	0.01	0.03	0.58
3.C.5	Indirect N_2O Emissions from managed soils	N_2O	1,020.23	2,443.77	0.02	0.05	0.63
3.C.1	Emissions from biomass burning	N_2O	403.58	70.89	0.03	0.06	0.69
3.C.1	Emissions from biomass burning	CH_4	327.81	71.36	0.02	0.05	0.74
1.A.1	Energy Industries - Liquid Fuels	CO_2	328.40	359.08	0.01	0.02	0.76
1.A.3.e	Other Transportation	CO_2	596.75	1,683.49	0.03	0.05	0.81
1.A.3.c	Railways	CO_2	308.25	466.90	0.00	0.01	0.82
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	0.00	569.28	0.02	0.05	0.86
3.A.2	Manure Management	CH_4	175.23	334.00	0.00	0.00	0.87
1.B.2.a	Oil	CH_4	0.00	409.66	0.02	0.04	0.90
2.A.1	Cement production	CO_2	194.83	522.53	0.01	0.01	0.92
2.A.2	Lime production	CO_2	77.25	52.65	0.00	0.01	0.92
1.A.4	Other Sectors - Solid Fuels	CH_4	65.69	58.47	0.00	0.01	0.93
1.B.1	Solid Fuels	CH_4	130.91	692.75	0.02	0.04	0.97
1.A.3.e	Other Transportation	N_2O	71.40	201.43	0.00	0.01	0.97
1.A.3.b	Road Transportation	N_2O	39.31	71.86	0.00	0.00	0.97
4.A	Solid Waste Disposal	CH_4	15.33	155.63	0.01	0.01	0.99
1.A.1	Energy Industries - Solid Fuels	N_2O	28.95	52.18	0.00	0.00	0.99
2.D	Non-Energy Products from Fuels and Solvent Use	CO_2	12.89	0.04	0.00	0.00	0.99
4.D	Wastewater Treatment and Discharge	CH_4	27.90	67.93	0.00	0.00	0.99
1.B.2.a	Oil	CO_2	0.00	32.81	0.00	0.00	0.99
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	7.69	1.50	0.00	0.00	0.99

1.A.3.c	Railways	N_2O	18.91	51.39	0.00	0.00	0.99
1.A.4	Other Sectors - Liquid Fuels	CO_2	18.05	50.93	0.00	0.00	1.00
4.D	Wastewater Treatment and Discharge	N_2O	12.39	27.27	0.00	0.00	1.00
1.A.3.b	Road Transportation	CH_4	7.76	13.63	0.00	0.00	1.00
1.A.4	Other Sectors - Biomass	CH_4	8.57	17.52	0.00	0.00	1.00
1.A.4	Other Sectors - Solid Fuels	N_2O	4.86	4.34	0.00	0.00	1.00
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CH_4	3.47	0.68	0.00	0.00	1.00
1.A.5	Non-Specified - Solid Fuels	N_2O	3.28	4.50	0.00	0.00	1.00
1.A.3.a	Civil Aviation	CO_2	5.97	30.27	0.00	0.00	1.00
1.A.4	Other Sectors - Biomass	N_2O	1.69	3.45	0.00	0.00	1.00
1.A.4	Other Sectors - Liquid Fuels	N_2O	2.16	6.09	0.00	0.00	1.00
1.A.1	Energy Industries - Solid Fuels	CH_4	1.31	2.36	0.00	0.00	1.00
1.A.1	Energy Industries - Biomass	N_2O	1.68	4.37	0.00	0.00	1.00
1.A.1	Energy Industries - Liquid Fuels	N_2O	0.80	0.90	0.00	0.00	1.00
1.A.1	Energy Industries - Biomass	CH_4	0.85	2.22	0.00	0.00	1.00
2.C.1	Iron and Steel Production	CO_2	0.00	1.22	0.00	0.00	1.00
1.A.3.e	Other Transportation	CH_4	0.70	1.98	0.00	0.00	1.00
2.F.2	Foam Blowing Agents	HFCs (HFCs)	0.00	1.05	0.00	0.00	1.00
2.F.3	Fire Protection	HFCs, PFCs	0.00	0.97	0.00	0.00	1.00
1.A.1	Energy Industries - Liquid Fuels	CH_4	0.27	0.30	0.00	0.00	1.00
1.A.3.c	Railways	CH_4	0.25	0.52	0.00	0.00	1.00
1.A.5	Non-Specified - Biomass	N_2O	0.23	0.47	0.00	0.00	1.00
1.A.5	Non-Specified - Solid Fuels	CH_4	0.15	0.20	0.00	0.00	1.00
1.B.2.a	Oil	N_2O	0.00	0.15	0.00	0.00	1.00
1.A.3.a	Civil Aviation	N_2O	0.05	0.26	0.00	0.00	1.00
1.A.4	Other Sectors - Liquid Fuels	CH_4	0.02	0.06	0.00	0.00	1.00
1.A.5	Non-Specified - Biomass	CH_4	0.01	0.02	0.00	0.00	1.00
1.A.3.a	Civil Aviation	CH_4	0.00	0.00	0.00	0.00	1.00
Total							
			23,648.79	43,081.62	0.49	1	

Annex III: Uncertainty assessment

Base year for assessment of uncertainty in trend: 1990, Year T: 2020

2006 IPCC Categories	*Gas*	*Base Year emissions or removals (Gg CO_2e)*	*Year T emissions or removals (Gg CO_2e)*	*Activity Data Uncertainty (%)*	*Emission Factor Uncertainty (%)*	*Combined Uncertainty (%)*	*Contribution to Variance by Category in Year T*	*Type A Sensitivity (%)*	*Type B Sensitivity (%)*	*Uncertainty in trend in national emissions introduced by emission factor uncertainty (%)*	*Uncertainty in trend in national emissions introduced by activity data uncertainty (%)*	*Uncertainty introduced into the trend in total national emissions (%)*
1.A - Fuel Combustion Activities												
1.A.1.a.i - Electricity Generation - Liquid Fuels	CO_2	124.22	350.45	5.00	6.14	7.92	0.05	0.12	0.07	0.74	0.46	0.76
1.A.1.a.i - Electricity Generation - Liquid Fuels	CH_4	0.11	0.30	5.00	228.79	228.84	0.00	0.00	0.00	0.02	0.00	0.00
1.A.1.a.i - Electricity Generation - Liquid Fuels	N_2O	0.31	0.88	5.00	228.79	228.84	0.00	0.00	0.00	0.07	0.00	0.00
1.A.1.a.ii - Combined Heat and Power Generation (CHP) - Liquid Fuels	CO_2	204.18	8.63	10.00	6.14	11.73	0.00	0.09	0.00	0.57	0.02	0.32
1.A.1.a.ii - Combined Heat and Power Generation (CHP) - Liquid Fuels	CH_4	0.17	0.01	10.00	228.79	229.01	0.00	0.00	0.00	0.02	0.00	0.00
1.A.1.a.ii - Combined Heat and Power Generation (CHP) - Liquid Fuels	N_2O	0.49	0.02	10.00	228.79	229.01	0.00	0.00	0.00	0.05	0.00	0.00
1.A.1.a.ii - Combined Heat and Power Generation (CHP) - Solid Fuels	CO_2	6,045.93	10,666.89	5.00	12.41	13.38	122.29	4.73	1.98	58.76	14.02	3,649.37
1.A.1.a.ii - Combined Heat and Power Generation (CHP) - Solid Fuels	CH_4	1.31	2.36	5.00	200.00	200.06	0.00	0.00	0.00	0.20	0.00	0.04
1.A.1.a.ii - Combined Heat and Power Generation (CHP) - Solid Fuels	N_2O	28.95	52.18	5.00	222.22	222.28	0.81	0.02	0.01	5.03	0.07	25.28
1.A.1.c.ii - Other Energy Industries - Solid Fuels	CO_2	0.00	7.10	5.00	12.41	13.38	0.00	0.00	0.00	0.02	0.01	0.00
1.A.1.c.ii - Other Energy Industries - Solid Fuels	CH_4	0.00	0.00	5.00	200.00	200.06	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.c.ii - Other Energy Industries - Solid Fuels	N_2O	0.00	0.00	5.00	222.22	222.28	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.c.ii - Other Energy Industries - Biomass	CH_4	0.85	2.22	5.00	245.45	245.51	0.00	0.00	0.00	0.19	0.00	0.04
1.A.1.c.ii - Other Energy	N_2O	1.68	4.37	5.00	304.55	304.59	0.01	0.00	0.00	0.48	0.01	0.23

Industries - Biomass												
1.A.2 - Manufacturing Industries and Construction - Solid Fuels	CO_2	1,483.22	295.07	5.00	5.00	7.07	0.03	0.72	0.05	3.59	0.39	13.06
1.A.2 - Manufacturing Industries and Construction - Solid Fuels	CH_4	3.47	0.68	5.00	5.00	7.07	0.00	0.00	0.00	0.01	0.00	0.00
1.A.2 - Manufacturing Industries and Construction - Solid Fuels	N_2O	7.69	1.50	5.00	5.00	7.07	0.00	0.00	0.00	0.02	0.00	0.00
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CO_2	5.97	30.27	5.00	4.17	6.51	0.00	0.01	0.01	0.03	0.04	0.00
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CH_4	0.00	0.00	5.00	100.00	100.12	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	N_2O	0.05	0.26	5.00	150.00	150.08	0.00	0.00	0.00	0.01	0.00	0.00
1.A.3.b - Road Transportation - Liquid Fuels	CO_2	1,228.52	2,375.14	5.00	3.07	5.87	1.17	0.99	0.44	3.04	3.12	19.02
1.A.3.b - Road Transportation - Liquid Fuels	CH_4	7.76	13.63	5.00	244.69	244.74	0.07	0.01	0.00	1.47	0.02	2.15
1.A.3.b - Road Transportation - Liquid Fuels	N_2O	39.31	71.86	5.00	209.94	210.00	1.37	0.03	0.01	6.49	0.09	42.10
1.A.3.c - Railways - Liquid Fuels	CO_2	151.64	427.78	5.00	2.02	5.39	0.03	0.15	0.08	0.30	0.56	0.41
1.A.3.c - Railways - Liquid Fuels	CH_4	0.18	0.50	5.00	150.60	150.69	0.00	0.00	0.00	0.03	0.00	0.00
1.A.3.c - Railways - Liquid Fuels	N_2O	18.14	51.18	5.00	200.00	200.06	0.63	0.02	0.01	3.52	0.07	12.41
1.A.3.c - Railways - Solid Fuels	CO_2	156.61	39.12	5.00	24.25	24.76	0.01	0.08	0.01	1.87	0.05	3.50
1.A.3.c - Railways - Solid Fuels	CH_4	0.07	0.02	5.00	200.00	200.06	0.00	0.00	0.00	0.01	0.00	0.00
1.A.3.c - Railways - Solid Fuels	N_2O	0.76	0.21	5.00	233.33	233.39	0.00	0.00	0.00	0.09	0.00	0.01
1.A.3.e.ii - Off-road - Liquid Fuels	CO_2	596.75	1,683.49	5.00	3.87	6.33	0.68	0.58	0.31	2.25	2.21	9.95
1.A.3.e.ii - Off-road - Liquid Fuels	CH_4	0.70	1.98	5.00	150.22	150.30	0.00	0.00	0.00	0.10	0.00	0.01
1.A.3.e.ii - Off-road - Liquid Fuels	N_2O	71.40	201.43	5.00	200.00	200.06	9.75	0.07	0.04	13.86	0.26	192.27
1.A.4.a - Commercial/Institutional - Solid Fuels	CO_2	2.77	4.77	5.00	12.46	13.43	0.00	0.00	0.00	0.03	0.01	0.00
1.A.4.a - Commercial/Institutional - Solid Fuels	CH_4	0.01	0.01	5.00	200.00	200.06	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.a - Commercial/Institutional - Solid Fuels	N_2O	0.01	0.02	5.00	217.78	217.84	0.00	0.00	0.00	0.00	0.00	0.00

1.A.4.b - Residential - Solid Fuels	CO_2	776.20	810.94	5.00	12.46	13.43	0.71	0.50	0.15	6.20	1.07	39.61
1.A.4.b - Residential - Solid Fuels	CH_4	51.26	57.91	5.00	200.00	200.06	0.81	0.03	0.01	6.73	0.08	45.28
1.A.4.b - Residential - Solid Fuels	N_2O	3.78	4.27	5.00	222.22	222.28	0.01	0.00	0.00	0.55	0.01	0.30
1.A.4.b - Residential - Biomass	CH_4	7.42	15.16	5.00	227.27	227.33	0.07	0.01	0.00	1.39	0.02	1.94
1.A.4.b - Residential - Biomass	N_2O	1.46	2.98	5.00	297.73	297.77	0.00	0.00	0.00	0.36	0.00	0.13
1.A.4.c.i - Stationary - Solid Fuels	CO_2	218.42	7.52	5.00	12.46	13.43	0.00	0.10	0.00	1.23	0.01	1.52
1.A.4.c.i - Stationary - Solid Fuels	CH_4	14.42	0.55	5.00	200.00	200.06	0.00	0.01	0.00	1.31	0.00	1.71
1.A.4.c.i - Stationary - Solid Fuels	N_2O	1.06	0.04	5.00	222.22	222.28	0.00	0.00	0.00	0.11	0.00	0.01
1.A.4.c.i - Stationary - Biomass	CH_4	1.15	2.36	5.00	227.27	227.33	0.00	0.00	0.00	0.22	0.00	0.05
1.A.4.c.i - Stationary - Biomass	N_2O	0.23	0.47	5.00	297.73	297.77	0.00	0.00	0.00	0.06	0.00	0.00
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	CO_2	18.05	50.93	5.00	6.14	7.92	0.00	0.02	0.01	0.11	0.07	0.02
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	CH_4	0.02	0.06	5.00	200.00	200.06	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	N_2O	2.16	6.09	5.00	236.36	236.42	0.01	0.00	0.00	0.50	0.01	0.25
1.A.5.a - Stationary - Solid Fuels	CO_2	673.10	898.31	5.00	5.00	7.07	0.24	0.47	0.17	2.34	1.18	6.87
1.A.5.a - Stationary - Solid Fuels	CH_4	0.15	0.20	5.00	5.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00
1.A.5.a - Stationary - Solid Fuels	N_2O	3.28	4.50	5.00	5.00	7.07	0.00	0.00	0.00	0.01	0.01	0.00
1.A.5.a - Stationary - Biomass	CH_4	0.01	0.02	5.00	5.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00
1.A.5.a - Stationary - Biomass	N_2O	0.23	0.47	5.00	5.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00
1.B.1 - Fugitive Emissions from Fuels - Solid Fuels												
1.B.1.a.ii.1 - Mining	CH_4	120.84	639.46	5.00	5.00	7.07	0.12	0.17	0.12	0.86	0.84	1.45
1.B.1.a.ii.2 - Post-mining seam gas emissions	CH_4	10.07	53.29	5.00	5.00	7.07	0.00	0.01	0.01	0.07	0.07	0.01
1.B.2 - Fugitive Emissions from Fuels - Oil and Natural Gas												
1.B.2.a.ii - Flaring	CO_2	0.00	31.51	5.00	5.00	7.07	0.00	0.01	0.01	0.03	0.04	0.00
1.B.2.a.ii - Flaring	CH_4	0.00	0.40	5.00	5.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2.a.ii - Flaring	N_2O	0.00	0.15	5.00	5.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2.a.iii.2 - Production and	CO_2	0.00	1.30	5.00	5.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00

Upgrading												
1.B.2.a.iii.2 - Production and Upgrading	CH_4	0.00	409.25	5.00	5.00	7.07	0.05	0.08	0.08	0.38	0.54	0.43
2.A - Mineral Industry												
2.A.1 - Cement production	CO_2	194.83	522.53	51.48	10.00	52.44	4.51	0.18	0.10	1.84	7.07	53.42
2.A.2 - Lime production	CO_2	77.25	52.65	2.00	2.00	2.83	0.00	0.04	0.01	0.09	0.03	0.01
2.C - Metal Industry												
2.C.1 - Iron and Steel Production	CO_2	0.00	1.22	10.00	25.00	26.93	0.00	0.00	0.00	0.01	0.00	0.00
2.D - Non-Energy Products from Fuels and Solvent Use												
2.D.1 - Lubricant Use	CO_2	12.89	0.04	10.00	50.09	51.08	0.00	0.01	0.00	0.29	0.00	0.08
2.F - Product Uses as Substitutes for Ozone Depleting Substances												
2.F.1.a - Refrigeration and Stationary Air Conditioning	CH2F2	0.00	3.23	15.00	39.46	42.22	0.00	0.00	0.00	0.02	0.01	0.00
2.F.1.a - Refrigeration and Stationary Air Conditioning	CHF2CF3	0.00	21.56	15.00	44.36	46.83	0.01	0.00	0.00	0.18	0.09	0.04
2.F.1.a - Refrigeration and Stationary Air Conditioning	CH2FCF3	0.00	7.22	15.00	53.16	55.24	0.00	0.00	0.00	0.07	0.03	0.01
2.F.1.a - Refrigeration and Stationary Air Conditioning	CF3CH3	0.00	11.86	15.00	30.00	33.54	0.00	0.00	0.00	0.07	0.05	0.01
2.F.1.b - Mobile Air Conditioning	CH2FCF3	0.00	525.42	35.00	71.96	80.02	10.61	0.10	0.10	7.03	4.84	72.80
3.A - Livestock												
3.A.1.a.ii - Other Cattle	CH_4	2,811.67	4,670.49	10.00	30.00	31.62	130.94	2.13	0.87	64.02	12.28	4,249.69
3.A.1.c - Sheep	CH_4	1,583.72	3,155.19	10.00	40.00	41.23	101.59	1.30	0.59	51.88	8.30	2,760.79
3.A.1.d - Goats	CH_4	538.20	2,910.63	10.00	40.00	41.23	86.45	0.78	0.54	31.28	7.65	1,037.24
3.A.1.e - Camels	CH_4	519.23	456.85	10.00	40.00	41.23	2.13	0.32	0.08	12.68	1.20	162.15
3.A.1.f - Horses	CH_4	855.04	1,547.48	10.00	40.00	41.23	24.44	0.67	0.29	26.81	4.07	735.44
3.A.1.h - Swine	CH_4	2.83	0.52	10.00	30.00	31.62	0.00	0.00	0.00	0.04	0.00	0.00
3.A.2.a.ii - Other cattle	CH_4	59.82	99.37	10.00	14.00	17.20	0.02	0.05	0.02	0.63	0.26	0.47
3.A.2.c - Sheep	CH_4	31.67	63.10	10.00	14.00	17.20	0.01	0.03	0.01	0.36	0.17	0.16
3.A.2.d - Goats	CH_4	11.84	64.03	10.00	14.00	17.20	0.01	0.02	0.01	0.24	0.17	0.09
3.A.2.e - Camels	CH_4	14.45	12.71	10.00	14.00	17.20	0.00	0.01	0.00	0.12	0.03	0.02
3.A.2.f - Horses	CH_4	51.78	93.71	10.00	14.00	17.20	0.02	0.04	0.02	0.57	0.25	0.38
3.A.2.h - Swine	CH_4	5.66	1.03	10.00	39.00	40.26	0.00	0.00	0.00	0.11	0.00	0.01
3.A.2.i - Poultry	CH_4	0.01	0.03	10.00	39.00	40.26	0.00	0.00	0.00	0.00	0.00	0.00

3.B - Land												
3.B.1.a - Forest land Remaining Forest land	CO_2	-29,358.76	-30,331.06	24.49	83.71	87.22	42,008.06	17.77	5.64	1,487.42	195.36	2,250,568.58
3.B.1.b.ii - Grassland converted to Forest Land	CO_2	-8.59	-4.31	50.00	81.73	95.81	0.00	0.00	0.00	0.38	0.06	0.15
3.B.1.b.iii - Wetlands converted to Forest Land	CO_2	0.00	-1.54	50.00	81.57	95.68	0.00	0.00	0.00	0.02	0.02	0.00
3.B.3.b.i - Forest Land converted to Grassland	CO_2	422.86	4.89	50.00	45.87	67.85	0.00	0.19	0.00	8.70	0.06	75.75
3.C - Aggregate sources and non-CO2 emissions sources on land												
3.C.1.a - Biomass burning in forest lands	CH_4	72.00	47.63	15.00	70.00	71.59	0.07	0.04	0.01	2.87	0.19	8.27
3.C.1.a - Biomass burning in forest lands	N_2O	58.80	38.90	15.00	70.00	71.59	0.05	0.03	0.01	2.34	0.15	5.51
3.C.1.c - Biomass burning in grasslands	CH_4	255.81	23.73	30.00	70.00	76.16	0.02	0.12	0.00	8.30	0.19	68.97
3.C.1.c - Biomass burning in grasslands	N_2O	344.78	31.99	30.00	70.00	76.16	0.04	0.16	0.01	11.19	0.25	125.33
3.C.4 - Direct N2O Emissions from managed soils	N_2O	2,984.13	6,729.39	43.59	400.00	402.37	44,009.10	2.60	1.25	1,038.84	77.13	1,085,133.71
3.C.5 - Indirect N2O Emissions from managed soils	N_2O	1,020.23	2,443.77	43.59	494.69	496.61	8,840.93	0.91	0.45	450.82	28.01	204,025.05
3.D - Other												
3.D.1 - Harvested Wood Products	CO_2	-82.70	159.50	30.00	60.21	67.27	0.69	0.01	0.03	0.44	1.26	1.77
4.A - Solid Waste Disposal												
4.A - Solid Waste Disposal	CH_4	15.33	155.63	51.96	129.83	139.84	2.84	0.04	0.03	4.64	2.13	26.10
4.D - Wastewater Treatment and Discharge												
4.D.1 - Domestic Wastewater Treatment and Discharge	CH_4	19.44	47.11	63.64	59.16	86.89	0.10	0.02	0.01	1.03	0.79	1.69
4.D.1 - Domestic Wastewater Treatment and Discharge	N_2O	12.39	27.27	14.14	188.36	188.89	0.16	0.01	0.01	2.00	0.10	3.99
4.D.2 - Industrial Wastewater Treatment and Discharge	CH_4	8.46	20.82	50.25	42.43	65.76	0.01	0.01	0.00	0.32	0.28	0.18
Total												
		Sum: --5,378.40	Sum: 12909.10				Sum: 95,361.70					Sum: 3,553,188.36
							Uncertainty in total inventory: 308.81					Trend uncertainty: 1,884.99

Annex IV: Land use change matrix for GHG inventory (ha) from 1986 to 2020

Land Category	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*1986-1989*
Forest	17,106,201							17,106,201
Cropland		4,849,915						4,849,915
Grassland	4,004	2,917	114,586,070					114,592,991
Wetland			3,476	3,254,810				3,258,286
Settlement		369			8,640,743			8,641,112
Otherland						7,557,939		7,557,939
No data							405,131	405,131
Grand Total	17,110,205	4,853,201	114,589,546	3,254,810	8,640,743	7,557,939	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*1990 Total*
Forest	17,104,090							17,104,090
Cropland		4,849,915						4,849,915
Grassland	2,111		114,592,911					114,595,023
Wetland			79	3,258,286				3,258,365
Settlement					8,641,112			8,641,112
Otherland						7,557,939		7,557,939
No data							405,131	405,131
1989	17,106,201	4,849,915	114,592,991	3,258,286	8,641,112	7,557,939	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*1991 Total*
Forest	17,104,090							17,104,090
Cropland		4,844,081						4,844,081
Grassland		5,834	114,591,499					114,597,333
Wetland				3,258,365				3,258,365
Settlement			47		8,641,112			8,641,160
Otherland			3,476			7,557,939		7,561,416
No data							405,131	405,131
Grand Total	17,104,090	4,849,915	114,595,023	3,258,365	8,641,112	7,557,939	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*1992 Total*
Forest	17,104,090							17,104,090
Cropland		4,838,247	10,429					4,848,676
Grassland		5,834	114,586,904					114,592,737
Wetland				3,258,365				3,258,365
Settlement					8,641,160			8,641,160
Otherland						7,561,416		7,561,416
No data							405,131	405,131
Grand Total	17,104,090	4,844,081	114,597,333	3,258,365	8,641,160	7,561,416	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*1993 Total*
Forest	17,104,090							17,104,090
Cropland		4,832,973						4,832,973
Grassland		8,751	114,589,261					114,598,012
Wetland				3,258,365		79		3,258,445
Settlement		6,953	3,476		8,641,160			8,651,589
Otherland						7,561,336		7,561,336
No data							405,131	405,131

Grand Total	17,104,090	4,848,676	114,592,737	3,258,365	8,641,160	7,561,416	405,131	156,411,575

Row Labels	Forest	Cropland	Grassland	Wetland	Settlement	Otherland	No data	1994 Total
Forest	17,104,090							17,104,090
Cropland		4,825,940						4,825,940
Grassland		7,033	114,594,536					114,601,568
Wetland				3,258,445		3,476		3,261,921
Settlement					8,651,589	109		8,651,697
Otherland			3,476			7,557,751		7,561,227
No data							405,131	405,131
Grand Total	17,104,090	4,832,973	114,598,012	3,258,445	8,651,589	7,561,336	405,131	156,411,575

Row Labels	Forest	Cropland	Grassland	Wetland	Settlement	Otherland	No data	1995 Total
Forest	17,104,090							17,104,090
Cropland		4,810,688	2,917					4,813,604
Grassland		15,252	114,541,968					114,557,221
Wetland				3,261,921				3,261,921
Settlement			56,683		8,651,697			8,708,380
Otherland						7,561,227		7,561,227
No data							405,131	405,131
Grand Total	17,104,090	4,825,940	114,601,568	3,261,921	8,651,697	7,561,227	405,131	156,411,575

Row Labels	Forest	Cropland	Grassland	Wetland	Settlement	Otherland	No data	1996 Total
Forest	17,104,090	3,476						17,107,566
Cropland		4,803,096						4,803,096
Grassland		7,033	114,557,221	178				114,564,431
Wetland				3,261,743				3,261,743
Settlement					8,708,380			8,708,380
Otherland						7,561,227		7,561,227
No data							405,131	405,131
Grand Total	17,104,090	4,813,604	114,557,221	3,261,921	8,708,380	7,561,227	405,131	156,411,575

Row Labels	Forest	Cropland	Grassland	Wetland	Settlement	Otherland	No data	1997 Total
Forest	17,104,295							17,104,295
Cropland		4,798,980						4,798,980
Grassland		4,116	114,564,431			3,476		114,572,023
Wetland				3,261,743				3,261,743
Settlement	3,271				8,708,380			8,711,651
Otherland						7,557,751		7,557,751
No data							405,131	405,131
Grand Total	17,107,566	4,803,096	114,564,431	3,261,743	8,708,380	7,561,227	405,131	156,411,575

Row Labels	Forest	Cropland	Grassland	Wetland	Settlement	Otherland	No data	1998 Total
Forest	17,104,295							17,104,295
Cropland		4,794,310	4,687					4,798,997
Grassland			114,567,336			125		114,567,461
Wetland				3,258,473				3,258,473
Settlement		4,670		3,271	8,711,651			8,719,591
Otherland						7,557,626		7,557,626
No data							405,131	405,131

Grand Total	17,104,295	4,798,980	114,572,023	3,261,743	8,711,651	7,557,751	405,131	156,411,575

Row Labels	Forest	Cropland	Grassland	Wetland	Settlement	Otherland	No data	1999 Total
Forest	17,101,379							17,101,379
Cropland		4,790,246						4,790,246
Grassland	2,917	8,751	114,563,985					114,575,652
Wetland				3,258,473				3,258,473
Settlement					8,719,591			8,719,591
Otherland			3,476			7,557,626		7,561,103
No data							405,131	405,131
Grand Total	17,104,295	4,798,997	114,567,461	3,258,473	8,719,591	7,557,626	405,131	156,411,575

Row Labels	Forest	Cropland	Grassland	Wetland	Settlement	Otherland	No data	2000 Total
Forest	17,093,334		2,523	317				17,096,174
Cropland		4,783,697						4,783,697
Grassland	8,045	2,964	114,531,535	3,654		217		114,546,416
Wetland			10,429	3,251,231				3,261,660
Settlement		109	353	3,271	8,719,591			8,723,323
Otherland		3,476	30,812			7,560,885		7,595,173
No data							405,131	405,131
Grand Total	17,101,379	4,790,246	114,575,652	3,258,473	8,719,591	7,561,103	405,131	156,411,575

Row Labels	Forest	Cropland	Grassland	Wetland	Settlement	Otherland	No data	2001 Total
Forest	17,095,647		224					17,095,871
Cropland		4,780,780		3,476				4,784,256
Grassland	528	2,917	114,589,725	3,968	3,476			114,600,614
Wetland				3,254,057				3,254,057
Settlement			10,494		8,719,847	109		8,730,450
Otherland			45,972	159		7,595,065		7,641,196
No data							405,131	405,131
Grand Total	17,096,174	4,783,697	114,646,416	3,261,660	8,723,323	7,595,173	405,131	156,511,575

Row Labels	Forest	Cropland	Grassland	Wetland	Settlement	Otherland	No data	2002 Total
Forest	17,094,815	3,476	75					17,098,366
Cropland		4,776,585	2,965					4,779,550
Grassland	1,056	4,116	114,439,498	3,556	7,032			114,455,257
Wetland				3,246,945				3,246,945
Settlement			5,772	3,476	8,723,418			8,732,666
Otherland		79	52,304	79		7,641,196		7,693,659
No data							405,131	405,131
Grand Total	17,095,871	4,784,256	114,500,614	3,254,057	8,730,450	7,641,196	405,131	156,411,575

Row Labels	Forest	Cropland	Grassland	Wetland	Settlement	Otherland	No data	2003 Total
Forest	17,095,727							17,095,727
Cropland		4,773,019	3,054	79				4,776,153
Grassland	2,639	3,476	114,448,386		3,476	15,672		114,473,649
Wetland				3,243,310				3,243,310
Settlement		3,054	3,349		8,729,190			8,735,592
Otherland			469	3,556		7,677,988		7,682,012
No data							405,131	405,131

Grand Total	17,098,366	4,779,550	114,455,257	3,246,945	8,732,666	7,693,659	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2004 Total*
Forest	17,095,199							17,095,199
Cropland		4,768,767						4,768,767
Grassland	528	4,116	114,441,982	3,476				114,450,102
Wetland				3,239,833				3,239,833
Settlement		3,271	31,667		8,735,592			8,770,530
Otherland						7,682,012		7,682,012
No data							405,131	405,131
Grand Total	17,095,727	4,776,153	114,473,649	3,243,310	8,735,592	7,682,012	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2005 Total*
Forest	17,095,199			303				17,095,503
Cropland		4,761,380	8,894	3,476				4,773,751
Grassland		4,116	114,413,153	3,476		3,945		114,424,690
Wetland			79	3,225,625				3,225,704
Settlement		3,271	16,098		8,770,530	109		8,790,007
Otherland			11,878	6,953		7,677,958		7,696,789
No data							405,131	405,131
Grand Total	17,095,199	4,768,767	114,450,102	3,239,833	8,770,530	7,682,012	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2006 Total*
Forest	17,095,378		256					17,095,634
Cropland		4,770,389						4,770,389
Grassland	125		114,419,827		2,965	79		114,422,996
Wetland				3,225,704				3,225,704
Settlement		3,363	4,607		8,787,042	321		8,795,333
Otherland						7,696,388		7,696,388
No data							405,131	405,131
Grand Total	17,095,503	4,773,751	114,424,690	3,225,704	8,790,007	7,696,789	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2007 Total*
Forest	17,093,066							17,093,066
Cropland		4,766,504	6,109					4,772,613
Grassland	331		114,401,560	1,213	12,070	79		114,415,254
Wetland			4,153	3,224,491		580		3,229,224
Settlement	2,237	3,884	10,594		8,783,263	964		8,800,942
Otherland			580			7,694,764		7,695,344
No data							405,131	405,131
Grand Total	17,095,634	4,770,389	114,422,996	3,225,704	8,795,333	7,696,388	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2008 Total*
Forest	17,091,190							17,091,190
Cropland		4,772,534						4,772,534
Grassland	1,876		114,301,953			4,201		114,308,030
Wetland				3,229,224				3,229,224
Settlement		79	36,731		8,800,942	643		8,838,396
Otherland			76,570			7,690,500		7,767,071
No data							405,131	405,131

Grand Total	17,093,066	4,772,613	114,415,254	3,229,224	8,800,942	7,695,344	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2009 Total*
Forest	17,090,134							17,090,134
Cropland		4,772,534						4,772,534
Grassland	1,056		114,303,899					114,304,954
Wetland				3,225,954				3,225,954
Settlement			4,131	3,271	8,838,396	3,536		8,849,333
Otherland						7,763,534		7,763,534
No data							405,131	405,131
Grand Total	17,091,190	4,772,534	114,308,030	3,229,224	8,838,396	7,767,071	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2010 Total*
Forest	17,090,134		224					17,090,359
Cropland		4,768,719	321					4,769,040
Grassland		544	114,278,167		3,476	12,070		114,294,258
Wetland				3,225,954				3,225,954
Settlement		3,271	21,532		8,845,857	964		8,871,624
Otherland			4,710			7,750,499		7,755,209
No data							405,131	405,131
Grand Total	17,090,134	4,772,534	114,304,954	3,225,954	8,849,333	7,763,534	405,131	156,411,575

Row Labels	Forest	Cropland	Grassland	Wetland	Settlement	Otherland	No data	2011 Total
Forest	17,089,843							17,089,843
Cropland		4,768,671			3,476			4,772,147
Grassland	424		114,239,455	469				114,240,348
Wetland				3,225,484	321			3,225,806
Settlement	92	369	24,992		8,867,826	1,304		8,894,583
Otherland			29,811			7,753,906		7,783,717
No data							405,131	405,131
Grand Total	17,090,359	4,769,040	114,294,258	3,225,954	8,871,624	7,755,209	405,131	156,411,575

Row Labels	Forest	Cropland	Grassland	Wetland	Settlement	Otherland	No data	2012 Total
Forest	17,088,715							17,088,715
Cropland		4,768,032	40					4,768,072
Grassland	806	4,116	114,202,029					114,206,951
Wetland				3,225,806				3,225,806
Settlement	321		36,894		8,894,583	92		8,931,891
Otherland			1,385			7,783,625		7,785,009
No data							405,131	405,131
Grand Total	17,089,843	4,772,147	114,240,348	3,225,806	8,894,583	7,783,717	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2013 Total*
Forest	17,088,715							17,088,715
Cropland		4,759,823			321			4,760,144
Grassland		8,231	114,199,712	1,456	800			114,210,199
Wetland			170	3,224,350				3,224,520
Settlement		18	6,204		8,930,769	2,572		8,939,563

Otherland			865			7,782,437		7,783,302
No data							405,131	405,131
Grand Total	17,088,715	4,768,072	114,206,951	3,225,806	8,931,891	7,785,009	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2014 Total*
Forest	17,088,715							17,088,715
Cropland		4,756,028						4,756,028
Grassland		4,116	114,172,192			4,201		114,180,509
Wetland				3,224,520				3,224,520
Settlement			11,625		8,939,563	339		8,951,527
Otherland			26,382			7,778,762		7,805,144
No data							405,131	405,131
Grand Total	17,088,715	4,760,144	114,210,199	3,224,520	8,939,563	7,783,302	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2015 Total*
Forest	17,088,437							17,088,437
Cropland		4,735,403						4,735,403
Grassland		17,355	114,173,557		321			114,191,233
Wetland			82	3,224,493				3,224,574
Settlement	279	3,271	6,870	27	8,951,206	321		8,961,974
Otherland						7,804,822		7,804,822
No data							405,131	405,131
Grand Total	17,088,715	4,756,028	114,180,509	3,224,520	8,951,527	7,805,144	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2016 Total*
Forest	17,088,437							17,088,437
Cropland		4,735,200						4,735,200
Grassland			114,184,946					114,184,946
Wetland				3,224,574				3,224,574
Settlement		203	6,287		8,961,974	321		8,968,786
Otherland						7,804,501		7,804,501
No data							405,131	405,131
Grand Total	17,088,437	4,735,403	114,191,233	3,224,574	8,961,974	7,804,822	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2017 Total*
Forest	17,087,786							17,087,786
Cropland		4,735,200						4,735,200
Grassland	651		114,184,224		5,056			114,189,931
Wetland				3,224,253				3,224,253
Settlement			629		8,963,730	964		8,965,324
Otherland			92	321		7,803,537		7,803,950
No data							405,131	405,131
Grand Total	17,088,437	4,735,200	114,184,946	3,224,574	8,968,786	7,804,501	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2018 Total*
Forest	17,087,135							17,087,135
Cropland		4,735,200						4,735,200
Grassland	651		114,186,674					114,187,325
Wetland				3,224,253				3,224,253
Settlement			3,257		8,965,324	321		8,968,902

Otherland						7,803,629		7,803,629
No data							405,131	405,131
Grand Total	17,087,786	4,735,200	114,189,931	3,224,253	8,965,324	7,803,950	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2019 Total*
Forest	17,086,857							17,086,857
Cropland		4,735,200						4,735,200
Grassland			114,183,733		12,070			114,195,803
Wetland				3,224,253				3,224,253
Settlement			3,592		8,956,832			8,960,424
Otherland	279					7,803,629		7,803,907
No data							405,131	405,131
Grand Total	17,087,135	4,735,200	114,187,325	3,224,253	8,968,902	7,803,629	405,131	156,411,575

Row Labels	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Otherland*	*No data*	*2020 Total*
Forest	17,086,857							17,086,857
Cropland		4,735,200						4,735,200
Grassland			114,193,903					114,193,903
Wetland				3,224,253				3,224,253
Settlement			1,901		8,960,424	321		8,962,646
Otherland						7,803,586		7,803,586
No data							405,131	405,131
Grand Total	17,086,857	4,735,200	114,195,803	3,224,253	8,960,424	7,803,907	405,131	156,411,575